

APRIL, 1959

No. 237



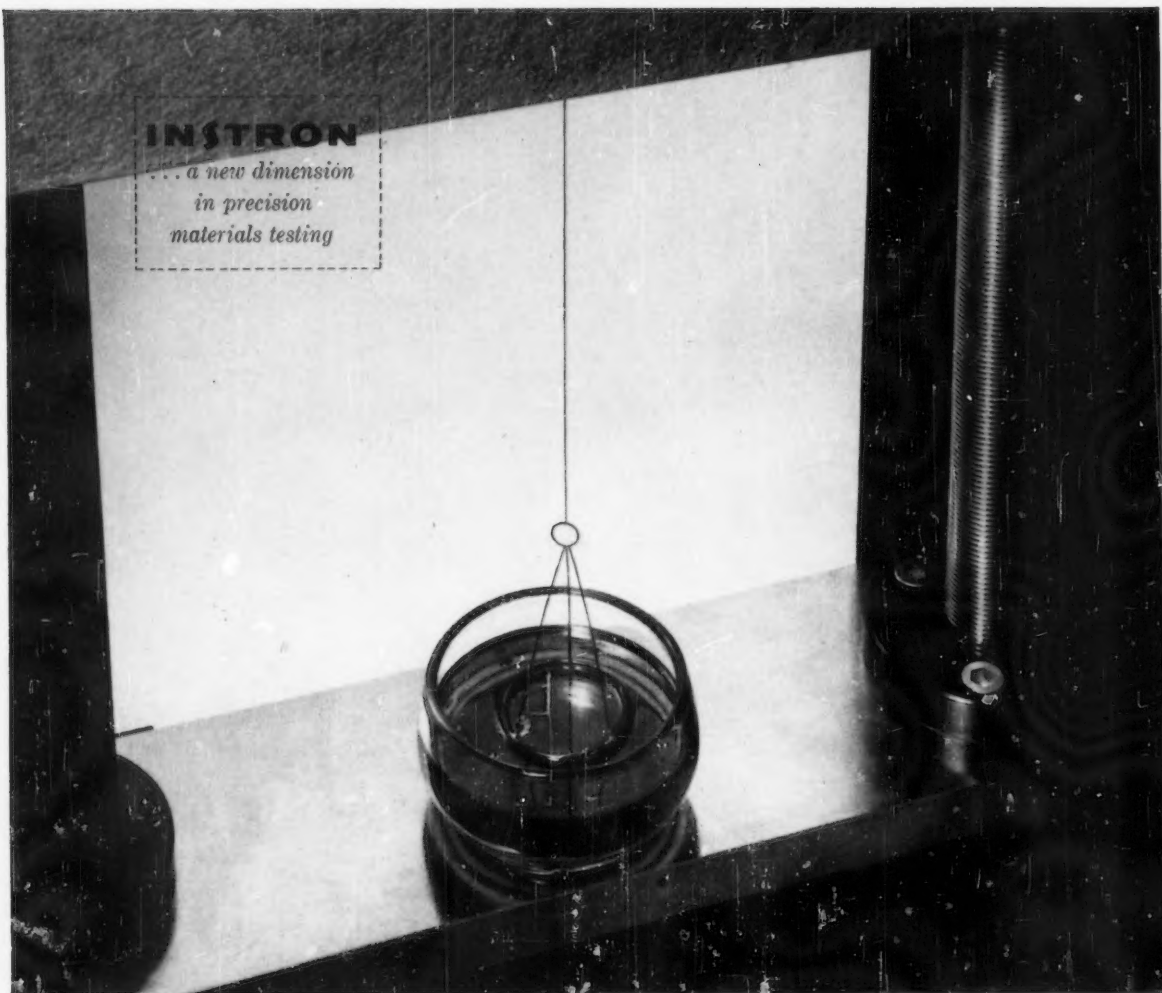
# Bulletin

Provisional Program  
62nd Annual Meeting  
Atlantic City—June 21-26

**American Society for Testing Materials**  
RESEARCH AND STANDARDS FOR MATERIALS

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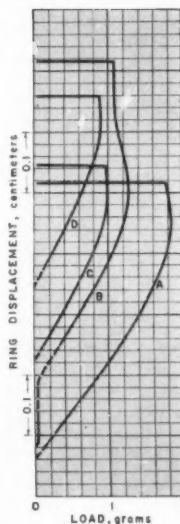


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# ASTM BULLETIN

April 1959

Number 237

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ASTM Bulletin is indexed regularly by Engineering Index Inc.  
ASTM Bulletin is available on microfilm from University Microfilms, Ann Arbor, Mich.

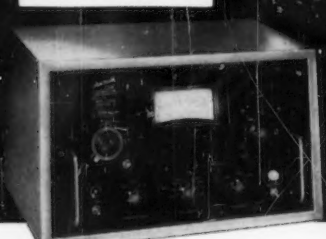
The Society is not responsible, as a body, for the statements and opinions advanced in this publication.

ASTM Bulletin, April 1959. Published eight times a year, January, February, April, May, July, September, October, and December, by the American Society for Testing Materials. Publication Office—20th and Northampton Sts., Easton, Pa. Editorial and advertising offices at the headquarters of the Society, 1916 Race St., Philadelphia 3, Pa. Subscriptions, United States and possessions, one year, \$3.50, two years, \$6.00, three years, \$8.50; Canada, one year, \$4.00, two years, \$7.00, three years, \$10.00. Other countries, one year, \$4.50, two years, \$8.00, three years, \$11.50. Single Copies—75 cents. Number 237. Second-class mail privileges authorized at Easton, Pa. This publication is authorized to be mailed at the special rates of postage prescribed by Section 132.123.

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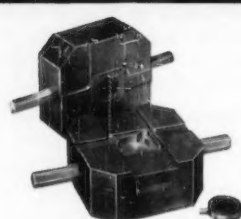
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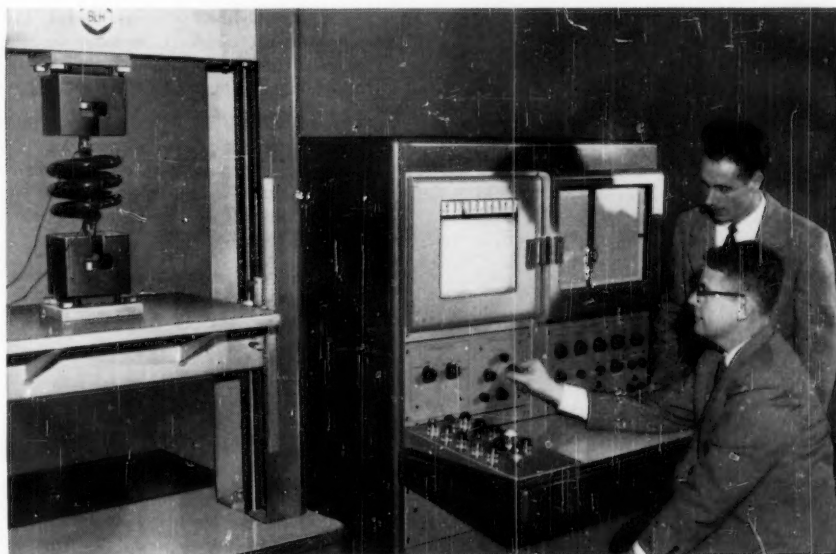
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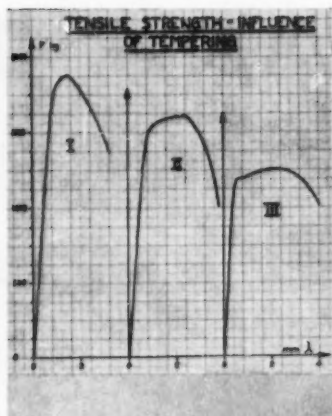
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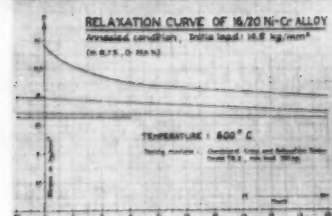
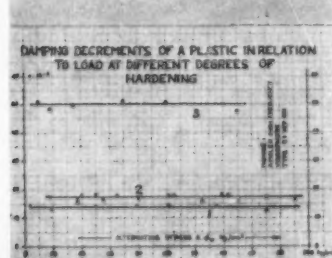
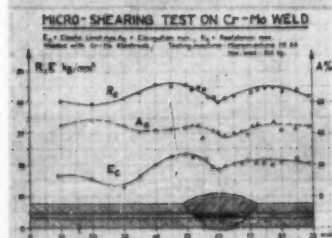
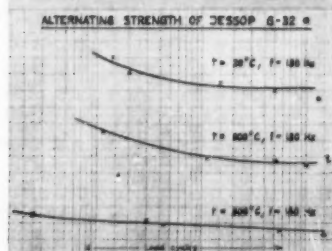
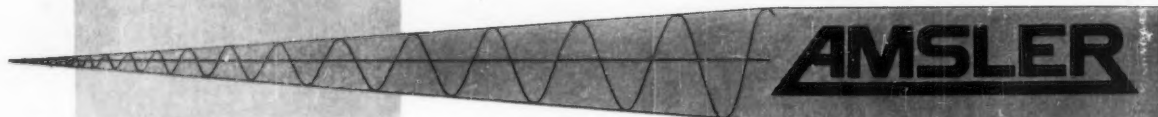




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FOR FURTHER INFORMATION CIRCLE 149 ON READER SERVICE CARD

ASTM BULLETIN

April 1959



# 62nd Annual Meeting

June 21-26  
Atlantic City

*Wide range of topics in technical program again demonstrates the broad coverage of the field of engineering materials in ASTM.*

THE 62ND ANNUAL MEETING of the Society will be held amid the atmosphere of an increasing awareness of the importance of materials to man's progress. The theoretical design capabilities of machines are outstripping the abilities of the materials available for making them. As the demands on our engineering materials increase, the outward pressures against the boundaries of our knowledge also increase.

## Symposia

The technical program includes eleven symposia:

### Education in Materials

Time Rates of Loading in Soil Testing Soils

Design of Bituminous Paving Mixtures

Atterberg Limits

Spectroscopic Excitation Sources

Tests and Properties of Bituminous Binders

Microscopy

Water Formed Deposits

Product Appearance

Use of Isotopes in the Analysis and Testing of Metals (Informal Symposium)

## Technical Sessions

In addition to the symposia, there will be sessions on the following subjects:

Concrete

Fatigue

Stainless Steel

Effect of Temperature on the Properties of Materials

General Testing

Cement

Road and Paving Materials

## Committee Meetings

A detailed schedule of technical committee meetings throughout the week will be included in the program distributed at the Annual Meeting. An advance tentative outline of these meetings was included in the April 3 letter to members transmitting the hotel reservation form. As has been pointed out in the letter, members should consider the committee meeting schedule as tentative, to be superseded by the call of the meetings by committee officers;

in other words, the official notice for committee and subcommittee meetings will be received directly from the secretary of each committee. As we go to press, the following committees plan to meet:

- A-1 Steel
- A-2 Wrought Iron
- A-3 Cast Iron
- A-5 Corrosion of Iron and Steel
- A-6 Magnetic Properties
- A-7 Malleable-Iron Castings
- A-9 Ferro-Alloys
- A-10 Iron-Chromium, Iron-Chromium-Nickel and Related Alloys
- B-2 Non-Ferrous Metals and Alloys
- B-3 Corrosion of Non-Ferrous Metals and Alloys
- B-4 Metallic Materials for Electrical Heating, Electrical Resistance, and Electrical Contacts
- B-5 Copper and Copper Alloys, Cast and Wrought
- B-6 Die-Cast Metals and Alloys
- B-7 Light Metals and Alloys, Cast and Wrought
- C-1 Cement
- C-2 Magnesium Oxide and Magnesium Oxysulfate Cements
- C-4 Clay Pipe
- C-7 Lime
- C-9 Concrete and Concrete Aggregates
- C-11 Gypsum
- C-12 Mortars for Unit Masonry
- C-15 Manufactured Masonry Units
- C-17 Asbestos-Cement Products
- D-1 Paint, Varnish, Lacquer and Related Products
- D-2 Petroleum Products and Lubricants
- D-3 Gaseous Fuels
- D-4 Road and Paving Materials
- D-5 Coal and Coke
- D-6 Paper and Paper Products
- D-8 Bituminous Materials for Roofing, Waterproofing, and Related Building or Industrial Uses
- D-9 Electrical Insulating Materials
- D-11 Rubber and Rubber-Like Materials
- D-16 Industrial Aromatic Hydrocarbons and Related Materials
- D-17 Naval Stores
- D-18 Soils for Engineering Purposes
- D-19 Industrial Water
- D-20 Plastics
- D-24 Carbon Black
- D-25 Casein and Similar Protein Materials
- D-26 Halogenated Organic Solvents
- D-27 Electrical Insulating Liquids and Gases
- E-1 Methods of Testing
- E-2 Emission Spectroscopy

- E-3 Chemical Analysis of Metals
- E-4 Metallography
- E-7 Nondestructive Testing
- E-9 Fatigue
- E-12 Appearance
- E-15 Analysis and Testing of Industrial Chemicals
- F-1 Sub. IX on Materials Analyses
- Joint Committee on Effect of Temperature on the Properties of Metals
- Administrative Committee on Education in Materials
- Advisory Committee on Corrosion
- Administrative Committee on District Activities

## Luncheons

### President's Luncheon

The Society's main function dealing exclusively with ASTM affairs and personalities is the President's Luncheon to be held on Tuesday noon. Featured will be the President's address by retiring President Kenneth B. Woods; awards of Honorary Memberships to individuals of widely acknowledged eminence in the fields of work covered by the Society or those who have rendered especially meritorious service to the Society; awards to individuals who have rendered distinguished service to the Society along technical lines; and recognition of 50- and 40-year members.

### Education in Materials Luncheon

At the Education in Materials Luncheon, Monday, noon, June 22, Dr. Eric A. Walker will discuss the current debate concerning American education which is so much in the minds of the public—a debate that has often been conducted more along the lines of an

### The Provisional Program

of the 62nd Annual Meeting which begins on page 8 is designed to give a comprehensive preview of the symposia, sessions, and special events of the meeting. Brief abstracts are given of the papers to be presented and statements of the scopes of the symposia.

The official program which registrants will receive at the meeting will contain full and final details of the sessions, a complete schedule of committee meetings, and the when and where of entertainment features of the week.

argument than along those of an examination or discussion. He will describe the National Defense Education Act of 1958 which he considers the single most important piece of federal legislation concerning education in the United States since Abraham Lincoln signed the Morrill Land-Grant Act into law 97 years ago.

As Dr. Walker will point out, education must be provided at increasingly higher levels to increasing numbers of people and we must realize that our schools, colleges, and universities do not operate in a social vacuum and that the general attitudes held by the public have much to do with the kind of job the schools, colleges, and universities can and will do for our children.

DR. WALKER was born in Long Eaton, England, and educated in the United States. He was graduated from Harvard University in 1932 with a bachelor of science degree; in 1935 he received a master's degree in business administration and his doctorate in engineering, both from Harvard University. He holds honorary doctor of laws degrees from Temple University, Lehigh University, and Elizabethtown College.

Before joining The Pennsylvania State University, Dr. Walker was associated with Tufts College (1933-1939), University of Connecticut (1940-1942), and the Harvard Underwater Sound Laboratory (1942-1945). In 1945 he joined the Penn State staff as head of the Department of Electrical



**Ellis L. Armstrong, U. S. Commissioner of Public Roads, who will address the Highway Materials Industry Luncheon, Wednesday, June 24.**

### Highway and Highway Materials Luncheon

A Highway Materials Industry Luncheon will be held on Wednesday noon, June 24. The Honorable Ellis L. Armstrong, Commissioner of Public Roads, will be the guest speaker. "Research—A Forward Look," the title of his talk, is a most appropriate one as Mr. Armstrong will be discussing the importance of keeping a forward look on research to develop and improve materials and to obtain quality materials primarily in connection with our highway program. The toastmaster will be Professor Harmer E. Davis, director of the Institute of Transportation and Traffic Engineering, University of California, Berkeley.

Engineering and director of the Ordnance Research Laboratory, and in 1951 he became dean of the College of Engineering and Architecture. He served as vice-president of the University from 1951 until he became its president in 1956. His professional activities, past and present, include: Member, Army's Scientific Advisory Panel and Naval Research Advisory Committee; vice-chairman, President's Committee for Scientists and Engineers, appointed in 1956 by President Eisenhower; former chairman and member, National Research Council Committee on Undersea Warfare; executive secretary, Research and Development Board, 1950-1951; chairman, National Science Foundation Committee for Engineering, 1951-1953; vice-president, American Society for Engineering Education, 1952-1954; chairman, Engineering College Research Council, 1952-1954.

MR. ARMSTRONG, a native of Utah, received his bachelor of science degree in civil engineering from Utah State University in 1936. He did graduate work at Utah and Colorado State Universities. During 18 years' service with the U. S. Bureau of Reclamation, Mr. Armstrong was active in the design and construction of dams, railroads, and highways throughout the West. He was field and office engineer on the Anderson Ranch Dam (the world's highest earth fill) in Idaho, and project engineer in charge of the Trenton Dam project on Republican River, Nebr. For 3 years he was in charge of the design section in the office of the chief engineer in Denver, Colo.

In 1953 Mr. Armstrong served as engineer member of the Egyptian-American Rural Improvement Commission, Cairo, Egypt, planning the development of land, water, and transportation re-

### For the Ladies . . .

Monday through Thursday mornings—Coffee hour.

Throughout the week—Golfing privileges at Seaview Country Club and Atlantic City Country Club (for members and wives).

Throughout the week—Sightseeing boat trips along the coast.

Tuesday evening—Slide-illustrated lecture by President Woods—topic: the Arctic.

Wednesday—Bus trip to Cape May, N. J., with stops at historic and other places of interest. Luncheon.

Wednesday—Dinner and entertainment sponsored by the Philadelphia District.



**Eric A. Walker, president, The Pennsylvania State University, who will address the Education in Materials Luncheon, Monday, June, 22.**

sources. He also acted as special consultant to the Egyptian government on the High Aswan Dam project. In 1954 he became project engineer on the power portion of the St. Lawrence Seaway for consulting engineers managing the project for the Power Authority of the State of New York. Appointed director of highways for the State of Utah in 1957, Mr. Armstrong reorganized the highway department for effective implementation of Utah's accelerated highway program. He was sworn in as U. S. Commissioner of Public Roads in October, 1958. Organizations with which he is affiliated include the American Society of Civil Engineers, the American Association of State Highway Officials, and the U. S. Committee on Large Dams.

## EDGAR MARBURG LECTURE



### THE MARBURG LECTURER . . .

Herman F. Mark was born in Vienna, Austria, and studied at the University of Vienna, obtaining his Ph.D. in 1921. In the same year, he became instructor at the University of Berlin and one year later joined the

Kaiser Wilhelm Institut for Chemistry of Fibrous Materials in Berlin-Dahlem where he worked first as research fellow, later as supervisor, and finally as group leader until 1926.

In 1927, he joined the research staff of the I. G. Farbenindustrie in Ludwigshafen (Rhine) and in 1932 was appointed professor of chemistry and director of the First Chemical Institute at the University of Vienna, Austria, where he stayed until 1938. Leaving Europe in 1938, he became research manager of the Canadian International Paper Co. in Hawkesbury, Ont.

In 1940, Dr. Mark became adjunct professor of organic chemistry at the Polytechnic Institute of Brooklyn, where he was promoted to full professor in 1942 and appointed director of the Polymer Research Institute in 1946.

Dr. Mark is internationally known and respected as a scientist and teacher in X ray, structure of matter, and macromolecules. He is the author of about 350 original and review articles in many languages and of eleven books. He has honorary degrees from several European universities, holds memberships, some hon-

orary, in numerous scientific associations, and was honorary president of the American Society of European Chemists and Pharmacists in 1952. He represents the Polytechnic Institute of Brooklyn on ASTM Committees C-19 on Structural Sandwich Constructions and D-23 on Cellulose and Cellulose Derivatives.

### THE LECTURE . . .

During the last few years, new catalytic systems have been discovered and new methods of polymerization have been developed which permit the preparation of many organic polymers with a much higher degree of molecular regularity than was possible before. Some of these new materials have already found interesting and meaningful applications. Others are just now being investigated for profitable and promising uses. But besides their practical applicability these highly ordered macromolecules have also posed new fundamental questions of nomenclature, classification, and characterization. They force us to widen our scope and to expand the basic framework of polymer science so that we can adequately describe and interpret all the data assembled within the last few years.

## HORACE W. GILLET LECTURE



### THE GILLET LECTURER . . .

John C. Fisher, physicist, General Electric Co., is active in the fields of metal physics and research analysis.

### *The Role of Dislocations in Plastic Deformation (of Metals)*

A native of New York State, Dr. Fisher received his bachelor's degree in mathematics from Ohio State University in 1941 and his doctor of science in mechanical engineering from Massachusetts Institute of Technology in 1947. After graduation from Ohio State, Dr. Fisher joined Battelle Memorial Institute as a research engineer. In 1942 he became a member of the staff of Massachusetts Institute of Technology. In 1947 he became associated with the General Electric Research Laboratory, first as research associate, then in 1950 as manager, Physical Metallurgy Section, and in 1957 he achieved his present position as physicist.

A member of Phi Beta Kappa and Sigma Xi, Dr. Fisher has published a number of papers in the field of metal physics. He is visiting professor of

engineering, Massachusetts Institute of Technology, and adjunct professor of metallurgy, Rensselaer Polytechnic Institute.

### THE LECTURE . . .

It is now known that metals and other crystalline materials deform plastically through the motion of dislocations. These imperfections, which are wrinkles in the atomic layers of a crystal, have been observed by a number of experimental techniques, and their motion has been followed during the course of plastic deformation. High strengths can be achieved by eliminating dislocations entirely, or by the more common method of blocking their motion. At present the dislocation concept makes it possible to account, semiquantitatively, for the strength of alloys.

# Provisional Program

# Sixty-second Annual Meeting

## American Society for Testing Materials

Atlantic City, N. J.

June 21-26, 1959

MONDAY, June 22	TUESDAY, June 23	WEDNESDAY, June 24	THURSDAY, June 25	FRIDAY, June 26
<b>MORNING</b>				
1 Opening Session—Symposium on Education in Materials	8 Session on Fatigue (Cont.) 9 Session on Soils	Administrative Committee on Research Forum 18 Session on General Testing 19 Symposium on Spectroscopic Excitation Sources —11:15 a.m.— 20 Report Session (Reports C-13, C-14, C-16, C-18, C-19, C-20, C-21, C-22, E-5, E-6)	26 Session on Cement 27 Session on Road and Paving Materials —11:15 a.m.— 28 Report Session (Reports D-7, D-10, D-12, D-13, D-14, D-15, D-22, D-23, D-26)	33 Symposium on Microscopy (Cont.) 34 Symposium on Visual Aids for Standardizing and Communicating Product Appearance
—12:00 noon— Education Luncheon	—12:00 noon— 10 President's Luncheon	—12:00 noon— Highway Industry Luncheon		
<b>AFTERNOON</b>				
2 Symposium on Education in Materials (Cont.) 3 Session on Concrete —4:30 p.m.— 4 Report Session (Reports B-1, B-3, B-8, B-9, F-1)	11 Session on Steel 12 Symposium on Methods of Test for Design of Bituminous Paving Mixtures —4:30 p.m.— 13 Report Session (Reports A-2, A-6, A-7, A-10, B-6, C-3, C-4, C-8, C-12)	21 Session on General Testing (Cont.) 22 Symposium on Practical and Statistical Significance of Tests and Properties of Bituminous Binders —4:00 p.m.— 23 Report Session (Reports A-1, A-5, B-2, E-3, E-4) 24 Report Session (Reports C-7, C-9, D-1, D-3, D-5, D-8, D-18, D-25, D-27)	Administrative Committee on Nuclear Activities 29 Symposium on Microscopy —4:30 p.m.— 30 Report Session (Reports A-3, B-7, D-17, D-20, D-24, E-1, E-7, Jt. Comm. Leather)	—12:30 p.m.— 35 Report Session (Reports B-4, B-5, C-1, C-11, C-15, E-2, E-12, E-13) —12:30 p.m.— 36 Report Session (Reports D-2, D-4, D-6, D-9, D-11, D-16, E-11)
	—5:00 p.m.— 14 Marburg Lecture Herman F. Mark New Polymers— New Problems	—4:30 p.m.— 25 Gillett Lecture John C. Fisher The Role of Dislocations in Plastic Deformation		
<b>EVENING</b>				
5 Session on Concrete (Cont.) 6 Symposium on Time Rates of Loading in Soil Testing 7 Session on Fatigue	15 Session on Effect of Temperature (Report Jt. Ef. Temp.) 16 Symposium on Afterberg Limits 17 Symposium on Methods of Test for Design of Bituminous Paving Mixtures (Cont.)	Dinner	31 Symposium on Microscopy (Cont.) 32 Symposium on Identification of Water Formed Deposits (Report D-19)	

NOTE.—It is possible that some of the papers listed in the following provisional program will be presented by title only. Consult the final program for this information.



Monday, June 22

9:30 a.m.

First Session

### Opening Session

**Formal Opening of the Sixty-Second Annual Meeting: President K. B. Woods**

### Symposium on Education in Materials

**Jointly sponsored by The American Society for Engineering Education (ASEE) and ASTM**

Probably no facet of engineering education merits more discussion today than education in materials. How shall the various curricula handle materials? Shall the students be given courses involving specific information on the properties of families of materials, or shall they be given courses which fall in what we call the materials-science environment, involving a great deal more physics, chemistry, and mathematics? Is there any consensus in industry of what the graduate should know? Is industry satisfied with the broad basic approach and willing then to train the graduate in matters which will permit him to design, select materials, avoid excessive waste, and assure satisfactory service with economy? Are we not ready for an undergraduate course leading to a degree in materials engineering? What is a materials engineer? Can we say that a top-notch metallurgist is a materials engineer? Or an expert in the field of plastics? Can we assure ourselves that future generations of engi-

neers will be able to carry the responsibilities involved in code work, establishing rules or procedures, standards—all of the things that industry will continue to need? Is the phrase *medius titissimus ibis* (you will go safest in the middle course) really the answer? This symposium brings together for frank and friendly discussion viewpoints of responsible men in the field of engineering education and representatives of industry. Every engineer and engineering teacher will be interested in the discussions.

Among the leaders in industry and in engineering education who will participate in the symposium are the following: ASTM President Kenneth B. Woods, head, School of Civil Engineering, Purdue University; ASEE President William T. Alexander, dean of engineering, Northwestern University; ASTM Senior Vice-President (and nominee for president) F. L. LaQue, vice-president and manager, Development and Research Division, The International Nickel Co., Inc.; Glenn B. Warren, vice-president,

Turbine Division, General Electric Co., and president, The American Society of Mechanical Engineers; Glenn Murphy, Anson Marston Distinguished Professor of Engineering, head, Department of Theoretical and Applied Mechanics, Iowa State College, and vice-president, ASEE; John B. Wilbur, Department of Civil and Sanitary Engineering, Massachusetts Institute of Technology; Albert G. H. Dietz, acting head, Building Engineering and Construction, Massachusetts Institute of Technology, or a representative of MIT speaking for Professor Morris Cohen and Professor Dietz; and others.

Topics to be discussed in the morning session are:

**The ASTM Viewpoint on Education in Materials**

**The Educators' Viewpoint  
Industry's Viewpoint**

*(Continued in Second Session)*

Monday, June 22

12:00 Noon

### Educational Luncheon

**Speaker: Dr. Eric A. Walker, President, The Pennsylvania State University**

Monday, June 22

2:30 p.m.

Second Session

Held simultaneously with the Third Session

### Symposium on Education in Materials (Continued)

The following three papers will be presented in the afternoon session:

- Nature and Properties of Materials (ASEE Follow-Up Report on Evaluation of Engineering Education)
- Discussion of the above report from the viewpoint of the physicist and from the viewpoint of civil engineering
- Summary of a Survey on Projected Degree in Materials Engineering

Monday, June 22

2:30 p.m.

Third Session

Held simultaneously with the Second Session

### Session on Concrete

**Fundamental Characteristics of Pulverized Coal Fly Ashes.** L. J. Minnick, G. & W. H. Corson, Inc.

Data are presented relating to the basic properties and characteristics of fly ash. A critical analysis is made of the components of this heterogeneous material. The investigation used chemical and physical tests based on X-ray diffraction and fluorescent spectrographic analyses, microscopic examination, and a few DTA analyses. Some information is presented on basic reactions of fly ash with acids and alkalis. Pozzolan reactives are also considered using several

curing conditions, in mixtures made with high-calcium and dolomitic lime. The study also includes information obtained from a questionnaire sent to the fly ash producers regarding types of coal, methods of burning, and methods of collection.

**Studies of Limestone Aggregates by Fluid-Flow Methods.** W. L. Dolch, Purdue University.

A study was made of the usefulness of simple fluid-flow measurements in elucidating the pore structure of limestone coarse aggregates. A correlation was sought with

the durability histories of pavements made with limestone aggregates. Five limestones with well established durability histories were tested. The tortuosities, slip factors, and average pore radii had no relation to the durability histories. The poor quality materials had higher porosities, permeabilities, specific surfaces, and absorptivities than did the good quality materials. Also, the poor quality materials in every case had higher rates of saturation and higher absorptivity-to-permeability ratios. The usefulness of the methods and principles used in evaluating the quality of coarse aggregates for use in portland-cement concrete is discussed.

(Third Session Continued)

**Effectiveness of Mineral Admixtures in Preventing Excessive Expansion of Concrete Due to Alkali-Aggregate Reaction.** *L. Pepper and Bryant Mather, U. S. Army Engineer Waterways Experiment Station.*

Twenty materials, representing 8 different classes of mineral admixtures, were evaluated using both chemical and mortar-bar test methods, for their effectiveness in preventing excessive expansion of concrete due to alkali-aggregate reaction. The criteria of the

chemical tests were examined and the test results were compared with the mortar-bar test results. All results were compared with those obtained by two other laboratories. It was found that the chemical tests cannot be used with reliance to evaluate effectiveness and that the mortar-bar test procedure needs improvement to increase its precision. Each of the replacement materials evaluated will prevent excessive expansion if a sufficient quantity is used. Correlations were found between effectiveness and: fineness, dissolved silica, and percentage of alkali retained by reaction product.

(Continued in Fifth Session)

**Control Testing for Separation of Lightweight Material from Aggregate.** *E. C. Higginson and G. B. Wallace, U. S. Bureau of Reclamation.*

A method of test developed in the U. S. Bureau of Reclamation laboratories for evaluating the effectiveness of large-scale separation of lightweight material from aggregate is described. The effects of the following variables on the accuracy of the test are evaluated: moisture content of aggregate, rate of absorption of heavy liquid by the aggregate, skimming *versus* decanting, and methods of washing heavy liquids from aggregate.

Monday, June 22

4:30 p.m.

Fourth Session

**Committee Report Session**

**B-1 on Wires for Electrical Conductors.** *D. Halloran, Chairman.*  
**B-3 on Corrosion of Non-Ferrous Metals and Alloys.** *K. G. Compton, Chairman.*

**B-8 on Electrodeposited Metallic Coatings.** *C. H. Sample, Chairman.*  
**B-9 on Metal Powders and Metal Powder Products.** *J. L. Bonanno, Chairman.*

**F-1 on Materials for Electron Tubes and Semiconductor Devices.** *S. A. Standring, Chairman.*

Monday, June 22, Afternoon and Evening

**Symposium on Isotopes in the Analysis and Testing of Metals**

This informal symposium is being sponsored by Committee E-3 on Chemical Analysis of Metals. All those interested are invited to attend.

Monday, June 22

8:00 p.m.

Fifth Session

Held simultaneously with the Sixth and Seventh Sessions

**Session on Concrete (Continued)**

**Concrete for Shielding Nuclear Radiations.** *H. S. Davis, General Electric Co.*

Various types of concrete are described with reference to their physical and shielding properties. Heavy aggregates, cements, special compositions, boron additives, and placement methods also are covered. Current development programs are described briefly, as well as areas needing further investigation.

**An In-Place Strength Test for Low Density Concrete.** *I. A. Benjamin and G. D. Ralliff, Granco Steel Products Co.*

The force required to penetrate low-density concrete with a steel rod is a measure of the strength. Various rod sizes make it possible to test the concrete in place at early ages or maturity. Vermiculite, perlite, and foam-type concretes were tested. Several methods of penetrating the concrete were tried using penetrometers developed for testing soils. Both pocket-size and

larger instruments were used. The effect of needle size, depth of penetration, age of concrete, and methods of curing were studied. Test results were calibrated against conventional compression tests. A straight-line relation was found to exist between penetration resistance and compression tests on 2 by 2 in. cubes.

**Stresses in Deep Beams Subjected to Central and Third Point Loading.** *M. E. Raville and F. J. McCormick, Kansas State College.*

A theoretical, elastic stress analysis of deep beams subjected to central and third-point loading was performed for several depth-length ratios, and for several cross sections. A clear picture is obtained of the stress situation in the middle third of the span of beams whose depth-length ratio is about one third. Results account for some of the difference between moduli of rupture in beams subjected to central and third-point loading. A photoelastic analysis of beams of comparable dimensions and loading

will be made in order to study the effects of the end supports on the stress distribution in the middle third of the beam and to obtain an over-all correlation of results.

**Effect of Length to Diameter Ratio on Compressive Strength of Different Concretes—A Cooperative Investigation.** *C. E. Kesler, University of Illinois.*

Nine laboratories participated in a program to determine the effect of length-to-diameter ratio of the specimen on the apparent compressive strength of concrete. The concrete strength, type of aggregate, specimen size, and curing were variables. A current ASTM Method gives only one set of correction factors, although a review of past research indicates that the correction factors would be different for different strengths. The cooperative study results in the same conclusions, and lightweight concretes are shown to require different correction factors than do normal-weight concretes.

Monday, June 22

8:00 p.m.

Sixth Session

Held simultaneously with the Fifth and Seventh Sessions

**Symposium on Time Rates of Loading in Soil Testing**

This symposium delineates the scope and nature of the influence of time-rates of loading on results of soil tests, describes the uses to be made of soil test data, collects the body of present knowledge on this subject, presents the best of laboratory and field experience with testing procedures, and formulates present ideas and conceptions

into a set of basic and systematic conceptions and working principles. Soil is the engineering material most influenced by time-rates of loading. A primary objective in preparing soil-test procedures is to develop a system of simulated service tests which yield reliable results having significant and direct application to practical problems of design and construction.

**Dynamic and Static Resistance of Cohesive Soil—1846 to 1958.** *W. S. Housel, University of Michigan.*

Starting with the classical work of Collin published in France in 1846, developments in evaluating the shearing resistance of cohesive

soils are discussed, citing research and practical experience from selected publications. Particular attention is given to methods that distinguish between the dynamic or temporary resistance of plastic clay and its permanent or static resistance. Data on the rate of load application are presented with the objective of establishing a definite relation between soil resistance and rate of deformation.

**Triaxial Strain Rate and Effective Stresses in Clay.** C. B. Crawford, National Research Council.

A number of triaxial compression tests with pore-water-pressure measurements on a marine clay common to eastern Canada and the United States suggest that a structural breakdown controls the level of pore water pressures. The structural breakdown appears to be related to the rate of strain. The implications of this phenomenon become apparent when test results are plotted on a Mohr diagram of stresses. It is shown that the failure envelope in terms of effective stresses is dependent on rate of strain application. The application of such test results in practice could be dangerous.

**A Method for Adjusting Strain-Rates to Obtain Pore Pressure Measurements in Triaxial Shear Tests.** W. Ellis and W. G. Holtz, U. S. Bureau of Reclamation.

Triaxial shear tests are performed in the Bureau of Reclamation laboratory on partially saturated soils in a sealed condition (undrained). Shear values obtained must be based on effective stresses within the specimen during the test rather than applied stresses. Accurate pore-pressure measurements must be made so that the effective stresses can be determined from:

$$\sigma = \sigma - u$$

where:

$\sigma$  = the stress applied,  
 $u$  = the pore pressure, and  
 $\sigma$  = the effective stress.

The Bureau usually measures pore pressure through special pervious end plates. The rate of strain must be adjusted so that

pore pressures throughout the specimen are equalized. A procedure is presented for determining this strain-rate, based upon establishing a continuous relationship between the strain, the compressibility of the pore fluid, and the resulting pore pressure.

**Apparatus for Testing Soils Under Repeated Loading.** H. B. Seed, University of California.

Various studies conducted in recent years have indicated the need for reliable information on soil deformations resulting from prolonged application of repeated stress. Apparatus for subjecting soil specimens to several hundred thousand repeated applications of deviator stress during triaxial-compression tests is described, together with the necessary modifications for tests in which both the major and minor principal stresses are repeatedly applied and released. Typical data obtained in both types of test are presented.

**Strain-Rate Behavior of Plastic Clay.** D. Burnister, Columbia University.

Clays are at present considered to possess relatively constant strength properties and to exhibit relatively constant stress-strain responses. Consequently simplified procedures are used and accepted for providing data on clay behavior. The most significant facts, however, concerning the strength properties and stress-strain responses of clays are that they are markedly influenced by the time-rate loading and are strongly strain-rate dependent. A new approach is presented, which involves the experimental determination of more representative, significant, and adequate consolidation and shearing-strength data by environmental testing of clay soils. This approach involves a new working hypothesis regarding clay soil behavior and responses under stress.

**Automation in Consolidation Testing.** R. H. Karol, Karol-Warner, Inc.

In the past decade, tremendous strides have been taken in developing new materials, machines, and manufacturing techniques. Knowledge of instrumentation and its application to machines and machine tools have made the word automation almost a household phrase. This paper discusses the

various phases of consolidation testing to which automation can be and has been applied. Electronic, mechanical, and hydraulic instrumentation are illustrated and described. The economic factors that control the marketability of such equipment are also discussed.

**Time Effects on the Consolidation of Clays.** G. A. Leonards, Purdue University and B. K. Ramiah, American Testing and Engineering Corp.

Systematic studies were conducted on duplicate samples of remolded clay to investigate the effects of rate and duration of loading on the compressibility and rate of compression of clays. Of particular significance is the effect of load duration and load increment ratio on the interpretation of the preconsolidation pressure; it is demonstrated that past consolidation pressure is not the only variable influencing the subsequent shape of the compressibility curve. Laboratory studies indicate that secondary compressions can be controlled by the use of suitable surcharges. Secondary compressions do not always vary linearly with the logarithm of time for long-duration loadings.

**The Use of Visco-Elastic Stress-Strain Laws in Soil Testing.** R. L. Schiffman, Rensselaer Polytechnic Institute.

The major emphasis in most soil testing is either of an inferential nature, or an environmental nature. Inferential testing develops empirical properties of soils by correlations with field performances. Such broad correlations have proved to be inaccurate and limited in use. Environmental testing is of direct use in determining design criteria for specific problems. This type of testing requires specialized specific-purpose tests. To eliminate fundamental deficiencies of the above testing approaches a basic postulation of stress-strain-time behavior is made. First, it is necessary to confirm stress-strain-time laws previously postulated and second, to ascertain numerical values for the controlling soil properties. An analytical basis is established for setting up stress-strain-time laws for soil materials, based on the conditions of visco-elastic stress-strain-time properties. This approach is applied to hydrostatic, unconfined, and triaxial-compression stress-strain-time laws.

Monday, June 22

8:00 p.m.

Seventh Session

Held simultaneously with the Fifth and Sixth Sessions

**Session on Fatigue**

**Tension, Compression, and Fatigue Properties of Several Steels for Aircraft Bearing Applications.** G. Sachs, R. Sell, and W. F. Brown, Jr., National Aeronautics and Space Administration.

The static tensile and compressive properties, and the rotating-beam fatigue strength for several heats of SAE 52100 and three vacuum-melted tool steels were established at room and elevated temperatures and over a range of hardnesses. Static tensile properties reached a maximum at a certain hardness level depending on the alloy. The various heats of SAE 52100 had nearly equal elastic limits and yield strengths in both tension and compression. However, property differences between the three tool steels were observed in the static tests. The fatigue strength ( $10^6$  cycles) of SAE 52100 remained essentially constant from about 52 to 65 Rockwell C, but was different for the various heats investigated, being highest for the vacuum-melted ma-

terial. At a hardness level of 62 Rc the 500 F static and fatigue strengths of the tool steels appeared superior to those of vacuum-melted SAE 52100 tested at 350 F.

**The Effect of Temper-Embrittlement on the Fatigue Properties and Damage Due to Fatigue Overstress of a 3140 Steel.** E. B. Mikus, Convair and C. A. Siebert, University of Michigan.

The fatigue properties of a severely temper-embrittled structure and a corresponding tough structure of 3140 steel were compared. Temper-embrittlement had no effect on the fatigue-life characteristics as determined by the rotating-beam type test. However, the response of the temper-embrittled structure to short periods of appreciable overstress followed by subsequent runs to failure at a lower stress was inferior to that of the tough structure. When the oversteering was carried out only slightly above the runout stress, both structures seemed to exhibit a coxing effect.

(Continued in Eighth Session)

**The Effect of Stress Cycling on the Static Mechanical Properties of SAE 4340 Steel.** J. Marin, P. Borachia, and U. Rinrott, Pennsylvania State University.

Various theories have been proposed to explain the mechanism of fatigue. Some of these are based upon the concept that materials have a certain available ductility and that under stress cycling, failure will occur when the resultant permanent strain has reached the value of the fracture strain under static loading. The results of this investigation do not support this "depletion of ductility" hypothesis. This study also investigated the influence of preycling on the static tensile properties of the material. Specimens of SAE 4340 heat-treated steel were preycled under axial tensile loading to various percentages of the fatigue life for the stress level selected. It was found that preycling produced small changes in the properties; it reduced the hardness and ductility but increased the ultimate strength and strain-hardening exponent.

Held simultaneously with the Ninth Session

**Fatigue Session (Continued)**

**Techniques and Equipment for Fatigue Testing at Very High Frequencies.** E. A. Neppiras, *Mullard Research Laboratories.*

Ultrasonic vibrators have recently been used as the basis of accelerated fatigue test devices. This paper deals with the design and performance of these high-frequency testers. The three essential parts of the vibrating system: the electromechanical transducer, the mechanical focussing system, and the specimen are considered separately and in detail. Complete test equipments are described capable of carrying out axial-load tests at frequencies of about 1,000,000 cycles per min. The modifications necessary for bending and torsion tests are discussed. Test results are given for a number of light alloys and steels. The advantages and limitations of very-high-frequency test methods are discussed.

**A Method for Determining the Fatigue Limit of Metals by Means of Stepwise Load Increase Test.** N. Enomoto, *Japanese National Railways.*

A method for predicting the Wöhler fatigue limit is proposed. The stress at failure in a progressively increasing load method of fatigue testing with only one loading is corrected to give the fatigue limit.

It is experimentally found that the effect of understressing did not influence the results when the loading rate was larger than a certain value but did when it was smaller than this value. The correction factor was obtained from published data of many progressively increasing load fatigue tests gathered from the literature. It was confirmed through experiments that there was no difference between the failure stress obtained from stepwise increasing load and linearly increasing load.

**The Effect of Internal Heating on the Fatigue Life of Titanium.** J. P. Romualdi, *Carnegie Institute of Technology* and E. D'Appolonia, *E. D'Appolonia Associates.*

A continuous record of temperature and deflection was obtained during fatigue tests of titanium specimens tested under isothermal and nonisothermal conditions, and at different stress levels and speeds. The bending moment-deflection relationship for a specimen, before the start of the test, was that which would be predicted on the basis of properties determined from a standard tensile test. After the first few cycles of repeated stress, however, for specimens stressed above the elastic limit, the deflection decreased to that which would be predicted from a linear elastic theory. When subsequent overheating due to rapid cyclic stressing was prevented, either by a coolant (isothermal test) or by slow testing speeds, this pseudoelastic deflection was maintained for almost the entire fatigue life of the specimen. Under nonisothermal conditions and rapid testing speeds, the deflection increased again and the temperature of the specimen rose. This temperature rise caused a thermal softening and the specimen had a ragged discolored fracture surface. When the stress was low enough there was no appreciable temperature rise and the specimen either failed due to a spreading fatigue crack or ran indefinitely.

**Anisotropy of Crack Initiation and Crack Propagation in Cold Rolled Aluminum Sheet.** H. A. Lipsitt, F. W. Forbes, and R. B. Baird, *Wright Air Development Center.*

Low-cycle, high-stress fatigue tests in fluctuating tension were performed on transverse and longitudinal specimens of sheet 1100-H18 aluminum alloy. The num-

ber of cycles required to initiate and to propagate a visible crack at the root of a mild semicircular notch was determined at several stresses. The data indicate that the growth of a fatigue crack is neither linear (on a semilog plot) nor continuous. Crack growth is seen to consist of short bursts of growth followed by periods of no measurable growth. In the initial stages the growth bursts are proportional to the stress and the rest period inversely proportional. Cracks in transverse specimens initiated sooner, propagated faster, and were finally shorter than those in longitudinal specimens before failure occurred. An explanation based on the metallurgical state of the material is offered to account for this anisotropy.

**Tensile and Fatigue Properties of Laminate Sheet Structures.** R. B. Baird, F. W. Forbes, and H. A. Lipsitt, *Wright Air Development Center.*

Laminated sheets of 1100-H18 aluminum foil oriented in various fashions with respect to one another and bonded with an epoxy resin were prepared. The mechanical properties of these structures were determined and compared with the properties of solid sheets of the same material. These structures were less dense than aluminum and had substantially the same properties in two directions. On a strength-per-density basis the structures had higher yield and ultimate tensile strengths than did a solid sheet. Less reduction in area and a definite reduction in the speed of final crack propagation were observed in the laminates. Under certain conditions the rapidly propagating crack stopped completely before destroying the structure. Laminates of 1100-O foil failed by the very slow propagation of a crack and little reduction in area. In a fatigue test the laminated sheet showed more resistance to the formation and propagation of a crack than did a solid sheet.

Held simultaneously with the Eighth Session

**Session on Soils**

**Laboratory and Field Tests of Cement-Treated Granular Base-Course Materials.** M. S. Abrams, *Portland Cement Assn.*

Data are presented on the strength and load-supporting properties of two sub-standard granular materials treated with various quantities of cement and subjected to freezing and thawing action. Bearing ratios, pulse velocities, and compressive strengths were determined in the laboratory. In the field, load-supporting values were obtained on 36 panels 4 ft square and 4, 7, and 10 in. thick. These load tests, made with a 12-in. diameter plate, were performed over a period of five years. Freezing and thawing action had a detrimental effect upon mixtures that contained less cement than required for hardened soil-cement. There was little or no effect due to frost action on hardened soil-cement material.

**Powder vs Slurry Application of Lime for Soil Stabilization.** D. T. Davidson, G. Noquera, and J. B. Sheeler, *Iowa State College.*

The use of lime in soil stabilization is rapidly gaining acceptance and both hydrated and quicklime have proved successful. Quicklime is less expensive and more effective than hydrated lime but the latter is easier and safer to handle in the powdered state. A possible answer to the safer use of quicklime lies in its application as a slurry. The effectiveness of limes in slurry form is evaluated and compared with stabilization using limes in powdered form. Slurries of lime were easily applied and produced unconfined compressive strengths equivalent to strengths obtained with powdered lime. Quicklimes used in slurries produced higher strengths than when used in powdered form, while hydrated limes gave about equal strengths in either form.

**Improved Determination of Preconsolidation Pressure.** J. J. Hamilton and C. B. Crawford, *National Research Council.*

Poor agreement between calculated and measured consolidation settlement in the Leda (Laurentian) clay of eastern Canada suggested that the classical consolidation theory may not apply to this soil. A limited laboratory evaluation of this suggestion was made. Conventional consolidation test results, where the loading is doubled with each increment, are open to wide interpretation of the preconsolidation pressure of the sample. The use of small loading increments improves the pressure-void ratio curve but may extend the test beyond practical time limits. Special tests at constant rate of stress increase or at constant strain rate indicated the preconsolidation pressure within a few hours.



Tuesday, June 23

12:00 noon

Tenth Session

### Luncheon Session

President's Address, Introduction of New Officers, 40-Year and 50-Year Members  
Recognition, Report of Board of Directors, Awards

Tuesday, June 23

2:30 p.m.

Eleventh Session

Held simultaneously with the Twelfth Session

### Session on Steel—Stainless

#### AISI Type 304L Stainless Steel with Improved Strength. *R. R. Brady, U. S. Steel Corp.*

An investigation was conducted to determine whether increasing the nitrogen content of type 304L stainless steel from the normal amount (0.04 per cent) to about 0.10 per cent would increase its room- and elevated-temperature mechanical properties without impairing its intergranular-corrosion resistance. On the basis of the results of Huey corrosion tests, room- and elevated-temperature tension tests, and creep-rupture tests, it is concluded that type 304L steel with about 0.10 per cent nitrogen will have (1) intergranular-corrosion resistance equivalent to that of type 304L steel with normal nitrogen content and (2) strength in the range of room temperature to 1500 F equal to that of the high-carbon type 304 steel.

#### Effect of Stress Relief on the Sharp Edge Notch Tensile Characteristics of Cold Rolled Austenitic Steel Sheet. *G. B. Espey, A. J. Repko, and W. F. Brown, Jr., National Aeronautics and Space Administration.*

Smooth and sharp-edge notch static tensile properties were established at room temperature and -321 F for cold-rolled AISI 301 and AISI 304 ELC sheet in both the rolling and the transverse directions. Various stress relief treatments were investigated. At room temperature notch sensitivity in the longitudinal direction was observed only for 70 per cent cold-reduced 301. High room-temperature notch sensitivity was observed in the transverse direction for specimens of both alloys cold worked more than about 40 per cent. At -321 F notch sensitivity developed in the longitudinal direction and was increased considerably in the transverse direction. Generally, the effects of stress relief on the notch sensitivity are quite complex and not entirely accounted for by known metallurgical influences. There was no pronounced reduction in the notch sensitivity produced by any of the stress relief treatments.

#### Effects of Alloying Additions on Hot Cracking of Austenitic Chromium-Nickel Stainless Steels. *F. C. Hull, Westinghouse Electric Corp.*

A quantitative study was made of the effects of various additions on hot cracking of austenitic chromium-nickel stainless steels by means of the cast pin tear test. Data are presented for the following elements over a fairly wide concentration range: aluminum, boron, carbon, chromium, cobalt, copper, columbium, hafnium, manganese, molybdenum, nickel, nitrogen, silicon, tantalum, titanium, tungsten, vanadium, and zirconium. The effects of these elements vary widely: some decrease the susceptibility to hot cracking and others are extremely detrimental, even in small amounts. These data provide information for the design of casting compositions or welding-electrode compositions of greatly improved resistance to hot cracking.

#### Relationships Between Composition and Properties of Austenitic Cr-Mn-C-N Stainless Steels. *A. Kasak, C. M. Hsiao, and E. J. Dulis, Crucible Steel Co. of America.*

Results show that the mechanical properties of austenitic Cr-Mn-C-N steels in the solution-annealed condition are related to the amounts of carbon and nitrogen in solid solution in austenite. By designing the composition and heat treating these steels according to the principles established in this study, a reasonably accurate estimate of the room- and elevated-temperature properties can be made. A nomograph for estimating hardness, yield strength, and tensile strength at room temperature and the 100-hr creep-rupture strength at 1200 F is presented. The effects of the carbon content and of cooling rate from the solution-annealing temperature on the room-temperature ductility are shown.

#### Property Relationships of Some Cast and Forged Cr-Mn-Ni-N Steels Containing 18 per cent Chromium. *K. Haefner, A. F. Lahr, W. L. Meinhardt, and J. J. Kanter, Crane Co.*

Steel compositions containing 18 per cent Cr, 0 to 18 per cent Mn, 0 to 18 per cent Ni, 0 to 0.5 per cent N, and approximately 0.1 per cent C were investigated. A study was made of the effect of variations of Mn, Ni, and N on phase relationships, nitrogen solubility (liquid-solid), forgeability, castability, mechanical and corrosion properties, and embrittlement. Both Mn and Ni increased the nitrogen solubility (liquid-solid). No susceptibility to intergranular corrosion attack in the forged condition (Strauss) was noted. Hardness, Charpy impact, metallographic, and X-ray diffraction studies were correlated with embrittlement. Embrittlement determined by impact test showed good agreement with microstructure. Hardness tests were not reliable criteria.

#### Effect of Chemistry and Processing Variables on Some Mechanical Properties of Large Ni-Mo-V Rotor Forgings. *K. H. Kramer and J. E. Steiner, U. S. Steel Corp.*

A multiple-regression analysis was used to estimate the coefficients in equations relating the impact and tensile properties of large Ni-Mo-V turbine and generator forgings to composition and processing variables. The analysis indicated that the fracture-appearance transition temperature increases with increased carbon, manganese, molybdenum, and phosphorus content, and increased austenitizing temperature, and that it decreases with increased nickel content and increased tempering temperature. The analysis also indicated that the tensile strength and yield strength increase with increased carbon, nickel, chromium, and molybdenum content, and decrease with increased tempering temperature.

Tuesday, June 23

2:30 p.m.

Twelfth Session

Held simultaneously with the Eleventh Session

### Symposium on Methods of Test for Design of Bituminous Paving Mixtures

This Symposium will describe new developments and present new data obtained by using the standard methods of test with application to the design of bituminous paving mixtures. During 1958, Committee D-4 adopted tentative standards for the Marshall stability test and the Hveem stabilometer and cohesionometer tests including the California kneading compactor. Also an extensive revision of the compressive strength test was completed. In view of these developments and the current interest in design of bituminous paving mixtures,

this Symposium has been planned. In addition to new data on standard test methods, a review of triaxial testing will be given. The new gyratory testing machine recently developed by the U. S. Corps of Engineers will be described and new data will be presented and interpreted.

#### General Factors in the Design of Bituminous Paving Mixtures (Introductory Paper). *L. F. Rader, University of Wisconsin.*

#### Theory and Application of a Gyratory Testing Machine for Hot-Mix Bituminous Pavement. *J. L. McKee and C. R. Foster, U. S. Army Engineer Waterways Experiment Station.*

The gyratory kneading-type machine, originally conceived by personnel of the Texas Highway Department, has been further developed to provide mechanical compaction of specimens to any given field condition. Indications are that it is also

(Twelfth Session Continued)

possible to evaluate the plastic properties of these specimens directly during the compaction process and by this means to determine the optimum bitumen content without the necessity of using voids criteria. A procedure is proposed for designing and controlling the construction of pavement for heavy airplane traffic. The gyratory testing machine and the proposed test procedures are described; also, proposed further development with this machine is discussed briefly.

**Application of Marshall Method in Hot Mix Design.** *H. L. Lehmann and V. Adam, Louisiana Department of Highways.*

The paper discusses the application of the Marshall method in designing hot mix

asphaltic concrete mixtures, the reproducibility of test results between different laboratories, the comparison of results obtained from samples proportioned and mixed in the laboratory with those proportioned and mixed at a plant, and the design criteria to be used for different types of mixtures for different traffic conditions. Two series of cooperative tests are discussed and the measures taken to improve the reproducibility are described and their effectiveness is shown. Correlation of results obtained in samples on several projects is discussed. Design criteria that have proved satisfactory are discussed briefly.

**Control of Bituminous Shoulder Construction for the Northern Illinois Toll Highway.** *J. J. Waddell, Knoerle, Graef, Bender and Associates, Inc.*

A total of 602,000 tons of hot plant-mixed bituminous concrete was required for the 3,664,000 sq yd of shoulders on the Toll Road. Asphaltic concrete for a shoulder of this type is subject to traffic conditions different from those on a main roadway, and therefore must be designed differently. To achieve the necessary properties uniformly and consistently, the Marshall method was used for designing the mixtures and controlling their proportioning, mixing, and compaction. A project of this size offered an excellent opportunity to study the effectiveness of the control method on a large volume of pavement using many different sources of materials, different types of equipment and varied methods of construction.

(Continued in Seventeenth Session)

Tuesday, June 23

4:30 p.m.

Thirteenth Session

**Committee Report Session**

**A-2 on Wrought Iron.** *L. S. Crane, Chairman.*

**A-6 on Magnetic Properties.** *A. C. Beiler, Chairman.*

**A-7 on Malleable-Iron Castings.** *W. M. Albrecht, Chairman.*

**A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys.** *L. L. Wyman, Chairman.*

**B-6 on Die-Cast Metals and Alloys.** *W. Babington, Chairman.*

**C-3 on Chemical-Resistant Mortars.** *J. R. Allen, Chairman.*

**C-4 on Clay Pipe.** *D. G. Miller, Chairman.*

**C-8 on Refractories.** *J. J. Hazel, Chairman.*

**C-12 on Mortars for Unit Masonry.** *R. E. Copeland, Chairman.*

Tuesday, June 23

5:00 p.m.

Fourteenth Session

**Marburg Lecture**

**New Polymers—New Problems**

Herman F. Mark, Director, Polymer Research Institute, Polytechnic Institute of Brooklyn

**Charles B. Dudley Medal Award**

The purpose of the Edgar Marburg Lecture is to have described at the annual meetings of the Society, by leaders in their respective fields, outstanding developments in the promotion of knowledge of engineering

**Richard L. Templin Award**

materials. Established as a means of emphasizing the importance of the function of the Society of promoting knowledge of materials, the Lecture honors and perpetuates the memory of Edgar Marburg, first Secre-

**Sam Tour Award**

tary of the Society, who placed its work on a firm foundation and through his development of the technical programs brought wide recognition to the Society as a forum for the discussion of properties and tests of engineering materials. [See abstract on p. 7.]

Tuesday, June 23

8:00 p.m.

Fifteenth Session

Held simultaneously with the Sixteenth and Seventeenth Sessions

**Effect of Temperature**

**Report of Joint Committee on Effect of Temperature on the Properties of Metals.** *J. J. Kanter, Chairman.*

**Creep-Rupture Behavior of Notched and Unnotched Specimens of Types 304, 316 and 321 Austenitic Stainless Steels.** *F. Garfalo, U. S. Steel Corp.*

The creep-rupture behavior of types 304, 316, and 321 austenitic stainless steels was investigated at 1100 and 1500 F using unnotched and notched specimens. At 1100 F, types 304 and 321 were notch-strengthened for rupture times less than 100 hr, but

between 100 and 1000 hr a slight notch-weakening effect was found. Beyond 1000 hr notch strengthening was again found. For type 316 a notch-strengthening effect was found at 1100 F. All three steels were notch-strengthened at 1500 F. A study of initiation and propagation of rupture at 1100 F in type 321 notched specimens shows that rupture initiates just beneath the notch and propagates intergranularly inward and to the notch surface. The crack is then arrested and an appreciable amount of plastic deformation follows. A new crack initiates at the specimen center and propagates outward to join the arrested crack.

**Effect of Environment on Creep and Creep-Rupture Behavior of Several Steels.** *F. Garfalo, U. S. Steel Corp.*

The creep and creep-rupture properties of several ferritic and austenitic stainless steels were determined from tests in air, in a purified mixture of helium plus 2 per cent hydrogen, and in vacuum at 1000 to 1200 F. The creep and creep-rupture properties were not affected by environment within the limits of the experiments performed. The change in slope of the log-log plot of stress versus rupture time for various steels tested in air was unchanged upon testing in vacuum or in inert atmosphere.

**Effect of Notch Geometry on the Tensile Properties at 100, 25, -78 and -196°C.**  
*G. W. Geil and N. L. Carwile, National Bureau of Standards.*

An experimental study was made to evaluate the combined effects of low temperatures and geometry of a circumferential notch on the tensile behavior of specimens of initially annealed commercially-pure titanium. The notch geometry was varied by changing its depth and root radius; the notch depth ranged from 5 to 87 per cent and the root radius from 0.005 to 2.0 in. True stress-true strain data were obtained at +100, +25, -78 and -196°C. The relationships of selected strength and ductility indices to the notch geometry and to the accompanying triaxiality and stress concentration factors are presented graphically and discussed in some detail.

**Stress-Strain Relations in Selected Titanium.** *E. P. Klier and C. Gazzara, The Catholic University of America.*

The plastic flow properties of three titanium alloys as a function of four strain rates and five temperature levels were studied. The stress-strain relationships were analyzed on the basis of the power law:

$\sigma = \sigma_0 \dot{\epsilon}^n$ , and were found to be characterized by three regions: (1) that dominated by the yield phenomenon associated with the strain-hardening exponent  $n_1$  and strength coefficient  $\sigma_{0,1}$ , (2) that related to a strain-hardening phenomenon describable by a second strain-hardening exponent  $n_2$  and strength coefficient  $\sigma_{0,2}$ , and (3) an intermediate strain region, represented by an overlapping of the two stress-strain curves, relative to regions (1) and (2) promoting a maximum intermediate stress.

**Properties of 70-30 Copper-Nickel Alloy at Temperatures Ranging up to 1050 F.**  
*W. F. Simmons, R. I. Jaffee, Battelle Memorial Institute, and D. N. Williams, B. J. Sirois, Phelps Dodge Copper Products Corp.*

This paper includes physical and mechanical properties for Cufenloy 30, a wrought 70 Cu, 29.1 Ni, 0.5 Fe, and 0.35 Mn alloy in the drawn and stress-relieved temper. The physical properties, thermal expansion, thermal and electrical conductivity, and electrical resistance are given for temperatures up to 750 F for thermal expansion and 572 F for the other properties. The mechanical properties include the short-time tensile properties and the long-time

creep-rupture properties to 1050 F. The data indicate the high-temperature strength properties are quite good and at 750 F, where the long-time creep properties become the controlling strength factor in design, the stress to produce a creep rate of 0.00001 per cent per hour is 15,000 psi.

**Mechanical Properties of a High Purity Lead and a 0.058 per cent Copper-Lead Alloy at Elevated Temperatures.** *T. E. Tietz, Stanford Research Institute.*

The tensile, compression, shear, bearing, and creep properties of a high-purity lead and a 0.058 per cent copper-lead alloy were evaluated at test temperatures of 100, 175, 250, and 325 F. The tensile stress-strain curve to fracture, the ultimate strength, elongation, modulus of elasticity, proportional limit, and yield strength were studied. Compression properties evaluated were the modulus of elasticity, proportional limit, yield strength, and stress-strain curve to 5 per cent strain. The ultimate shear strength and the bearing yield strength and ultimate bearing strength were determined. Stress-creep-time curves were obtained for total strain values of 0.2, 0.5, 1.0, and 2.0 per cent, for creep times of from 1 to 500 hr.

Tuesday, June 23

8:00 p.m.

Sixteenth Session

Held simultaneously with the Fifteenth and Seventeenth Session

## Symposium on Atterberg Limits

The Atterberg Limits are perhaps the oldest and the most widely used of all the engineering tests of cohesive soils. Unfortunately the apparatus and methods employed by various organizations throughout the United States and other countries differ. This leads to much uncertainty in evaluating the test data properly. Some of the apparatus and procedures now used are not entirely satisfactory because of excessive dependence on operator skill, non-suitability for certain types of slightly cohesive soils, and on the amount of time required to obtain satisfactory results.

It is the purpose of this symposium to discuss the effects of the different test procedures on the results, to compare different short cut methods now in use, and to examine alternate test methods which do not have the limitations of the present ASTM procedures. This symposium will be a guide to the appropriate committees in revising and strengthening the ASTM standards.

**History and Development of the Atterberg Limits Tests.** *E. E. Bauer, University of Illinois.*

A. Atterberg, a Swedish soil scientist, suggested in 1911 that clays can be classified according to the quantities of water required to meet certain arbitrary limits. He suggested six limits and one index number. Three of the six limits and the index number are in general use today: liquid limit, plastic limit, shrinkage limit, and plasticity index. The original Atterberg paper is reviewed and developments traced from 1911 to the present time. In order to reduce the time necessary to perform the ASTM liquid-limit test, several laboratories have taken advantage of Casagrande's observation about flow curves and have developed 1-point methods. These are reviewed. Included

also is a review of the styles of grooving tools used in cutting the groove in soil cakes in the liquid-limit test.

**The Use of a One-Point Liquid Limit Procedure.** *W. J. Eden, National Research Council*

The soil mechanics laboratory of the Division of Building Research has used a one-point liquid limit procedure for all routine tests since 1955. The decision to use the shortened method was based on a statistical study of three hundred and ninety previous tests made by a three-point method. Since that time, several hundred further tests have been made by the one-point method and checked by the three-point method on a number of occasions. A detailed procedure and description of apparatus is appended to the paper.

**Ohio Adopts the One-Point Mechanical Method for Determining the Liquid Limit of Soils.** *J. G. Joslin and H. D. Davis, Ohio State Highway Department.*

Ohio used the hand method of determining the liquid limit of soils for 21 years because it was faster than the 3-point mechanical method, time being an important factor in the soil testing program in Ohio. Prior to adopting the 1-point mechanical method a preliminary study was made on Ohio soils using three methods: the hand method, the 3-point mechanical method, and the simplified 1-point mechanical method. The 3-point mechanical method was used as the standard from which to reference all test data. A circular slide rule was developed by the Ohio State Highway Testing Laboratory to give the liquid limit from the 1-point mechanical method.

**Atterberg Limits for Deep Cores from Subsidence Areas in California.** *A. I. Johnson and D. A. Morris, U. S. Geological Survey.*

**Investigations of the Liquid Limit Test on Soils.** *R. F. Dawson, University of Texas.*

Results are given of check-tests on uniform samples by a number of commercial testing laboratories and also a laboratory investigation at the University of Texas, showing the effect of variation in testing equipment, adjustment of the equipment, testing methods, and procedures on the liquid limits of clay-type soils.

**Liquid Limit Results from Various Types of Grooving Tools.** *J. E. Mitchell, U. S. Army Engineer Waterways Experiment Station.*

The method of sample preparation for this study is given and the effect of variations in procedure on the results is discussed. The basic differences in the grooves made by each type of tool and their effects on test results are discussed. The action which forms the groove using each type tool is described and its probable effect on the results is analyzed. The advantages and disadvantages of each tool when used in various types of soil are given with methods for overcoming some of the difficulties encountered. The results obtained by the same operator for each tool are discussed. Results from the new flat type tool by Dr. Paul Hovanyi, as described in *Geotechnique*, June, 1958, are discussed.

(Sixteenth Session Continued)

**A Proposed Universal Standard Liquid Limit Test.** *M. D. Morris, Testlab Corp., T. D. Lewis, Ta Liang, R. B. Ulp, Cornell University, and R. A. Spinna, Manhattan College.*

There are so many ways to perform the liquid limit test, it was decided to investigate all combinations in order to evolve a single way to offer Committee D-18 a true tentative standard so that a liquid limit value will have universal value and significance. Variations on tool types, base types, direction of groove, condition of sample moisture, and clay types were run in combinations in independent studies at Cornell University and at Manhattan College. Only constants were the 25 blows and the technicians. The results (as yet untabulated) should indicate

which combination of tool-and-base, and grooving direction will turn out the most representative uniform result.

**Plastic-Limit—Comparison of Cube and Standard Methods.** *E. A. Abdun-Nur, Consulting Engineer.*

A description is given of the cube method of determining the plastic limit of soils, its history, advantages, and disadvantages, particularly as applied to soils of low plasticity. Data are given comparing results by this method and the standard thread method, and a correlation is developed from these data.

**Penetration Tests for Liquid Limit—The Russian Cone and Similar Devices.** *G. F. Sowers, A. Vesic, and M. Grondolf, Georgia Institute of Technology.*

The standard test for liquid limit is not wholly satisfactory in very sandy soils and some silty soils because of the difficulties in forming a proper groove and the tendency of the soils to slide in the cup. To overcome this difficulty Russian soil engineers have devised a cone penetrometer to define the point at which the soil becomes liquid. A similar device was used at the Georgia Institute of Technology in 1951. The cone penetration resistance of soils is compared with the liquid limit for various cones, including the Russian cone for which there is considerable experience.

Tuesday, June 23

8:00 p.m.

Seventeenth Session

Held simultaneously with the Fifteenth and Sixteenth Sessions

**Symposium on Methods of Test for Design of Bituminous Paving Mixtures (Continued)**

**Triaxial Testing of Bituminous Mixtures.** *W. H. Goetz and J. H. Schaub, Purdue University.*

The development of the triaxial shear strength theory and testing procedures as applied to bituminous mixtures are reviewed. The various triaxial testing procedures presently in use are compared. Emphasis is placed upon the desirability of triaxial procedures for use as design and research tools. Examples are presented of the use of triaxial testing methods to investigate the variables that must be considered in the testing of bituminous mixtures. The details of the various triaxial procedures used for the design of mixtures are reviewed. The testing methods discussed include those using both constant and variable lateral pressure.

**Correlation of Hveem Stabilometer and Cohesimeter Test Results and Kneading Compactor Densities with Service Records of Bituminous Pavements.** *C. E. Minor, Washington State Highway Commission.*

The design of a bituminous mix for maximum serviceability should be tempered by

its climatic environment, and the stabilometer, cohesimeter, and kneading compactor are useful tools in providing desirable design versatility. Densities obtained with the kneading compactor compare favorably with densities developed in the roadway after one or more years of service. The density of a bituminous pavement generally decreases with depth and the kneading compactor prepares a specimen with similar density distribution. The following factors influence the serviceability of heavy-duty bituminous pavements: traffic volume; climate; grade, quality, and quantity of asphalt; quality of aggregate; amount and type of dust; ratio of dust to sand; stabilometer and cohesimeter values of the mix; weather conditions at time of placing; and method of compacting in the field.

**Void Properties of Bituminous Paving Mixtures.** *N. W. McLeod, Imperial Oil Limited.*

The void properties of any dense graded bituminous paving mixture are at least as important as its stability insofar as the service performance of the finished pavement is concerned. With respect to its void properties, the three most important characteristics of a compacted paving mixture are: the quantity of bitumen absorbed by

the individual particles of aggregate, the intergranular void space between the aggregate particles, and the air voids between the coated particles of aggregate. The role of each of these three basic characteristics with respect to pavement performance, and the relationship between pavement behavior and paving mixture design are critically reviewed.

**The Use of the Immersion-Compression Test in Evaluating and Designing Bituminous Paving Mixtures.** *J. F. Goode, U. S. Bureau of public Roads.*

Several examples are given of the use of the immersion-compression test in evaluating stability and moisture resistance of mixtures and materials proposed for use in mixtures. A detailed description is given of a typical mix design illustrating the present use of the test by the Bureau of Public Roads together with other tests and design criteria used in setting up cold feed proportions and a job-mix formula for a dense-graded asphaltic concrete. This illustrated design shows and explains the use of such criteria as air voids, dust-asphalt ratio, stability, and retained strength. Suggested values of these criteria depending on traffic weight and type of base over which the pavement is to be placed are included.

Wednesday, June 24

9:30 a.m.

Held simultaneously with the Eighteenth and Nineteenth Sessions

**Administrative Committee on Research Forum**

The Administrative Committee on Research invites the officers of technical committees to participate in a forum session to discuss the place of research in the Society. Several members of the research committee will speak briefly and then officers of each committee will be called on in turn to express

their views on research in ASTM. While nearly everyone agrees that the development of adequate test methods and specifications for materials requires research background, there are wide differences of opinion on what constitutes research, as well as differences in attitude toward research in the Society's

80 technical committees. This forum will provide the committee officers an opportunity to exchange views on the importance of research to ASTM progress. A complete program for the forum will be mailed to the committee officers before the meeting and will be available to all at the meeting.



Wednesday, June 24

9:30 a.m.

Eighteenth Session

Held simultaneously with the Nineteenth Session

### Session on General Testing

**Development of ASTM Standard Reference Blocks for Ultrasonic Inspection.** *F. C. Panian, Aluminum Company of America and H. E. Van Valkenburg, Sperry Products, Inc.*

A review is given of the investigation which led to the development of the ASTM aluminum alloy ultrasonic standard reference blocks described in the Recommended Practice for Fabricating and Checking Aluminum Alloy Ultrasonic Standard Reference Blocks (E 127 - 58T). The physical variables affecting the ultrasonic response from the hole or artificial discontinuity in the blocks are discussed. Important considerations that illustrate the need for a fundamental comparison standard and for precise control of parameters and techniques of the ultrasonic tests used to evaluate the stock and the finished reference block are also included.

**A Cooperative Study of the Hardness Testing of Cemented Carbides.** *B. M. Caugherty, H. T. Oatman, and O. W. Reen, Allegheny Ludlum Steel Corp.*

To obtain a standard testing procedure for determining the Rockwell hardness of cemented carbides, a round-robin test program was conducted by a group of leading

carbide producers. The data obtained from test blocks of varying hardness levels were statistically analyzed. With common calibrating blocks, an expected range of variability of 0.4 to 0.6 Rockwell A points existed between any two companies. When each producer used his own internal test blocks, the expected range of variability between any two companies was 0.8 to 1.5 Rockwell A points. A metallographic study of the common calibrating blocks revealed microstructural variations which could account for the unexpectedly wide range of variability. In addition, the variables of the test procedure itself are contributing factors.

**New Joint Sealer Testing Machine Developed.** *R. J. Schutz and A. Van-Hauler, Sika Chemical Corp.*

A new joint sealer testing machine imparts direct tensile and compressive stresses to as many as six samples at one time. The machine fully meets Federal specifications for bond testing, and the loading method precludes development of shearing stresses. Failure of one specimen does not affect the loading of the other specimens in the machine. Movement may be geared to  $\frac{1}{4}$  in. per hr or per min. Loads may also be applied manually. Indicators on the machine may be calibrated to read bond at failure or stress during testing. Maximum

load at failure is also recorded. Adjustment may also be made for either stiff- or soft-joint compounds. Results of testing programs and other testing applications of the machine are discussed.

**Experimental Observations on the Relation Between Polarization Resistance and Corrosion Rate.** *M. Stern and E. D. Weisert, Union Carbide Metals Co.*

A method for determining corrosion rate from electrochemical measurements is described. The method uses a parameter called "polarization resistance" which is the slope of the polarization curve in the potential region very close to the corrosion potential. For most corroding systems, the corrosion rate can be estimated to within a factor of 4 by a simple measurement of the current required to polarize a few millivolts. Some knowledge of the electrochemistry of the system permits a much better estimate. An experimental calibration may be required in some cases. However, the calibration may be no better than the method of estimating described here, since measurement of instantaneous corrosion rate is particularly difficult. Data from a variety of published sources along with a number of new observations are used to support the correlation. The data presented extend over six orders of magnitude.

(Continued in Twenty-First Session)

Wednesday, June 24

9:30 a.m.

Nineteenth Session

Held simultaneously with the Eighteenth Session

### Symposium on Spectroscopic Excitation Sources

**Introductory Remarks.** *B. F. Scribner, National Bureau of Standards.*

**Advances in Knowledge of Excitation Phenomena.** *G. H. Dieke, John Hopkins University.*

**The Matrix Effect in Excitation.** *J. K. Hurwitz, U. S. Steel Corp.*

**Effects of Gaseous Atmospheres on Excitation.** *G. Adermann and J. W.*

*Kemp, Applied Research Laboratories.*

**Some Properties of New or Modified Excitation Sources.** *M. Margoshes, National Bureau of Standards.*

Wednesday, June 24

11:15 a.m.

Twentieth Session

### Committee Report Session

**C-13 on Concrete Pipe.** *R. R. Litehiser, Chairman.*

**C-14 on Glass and Glass Products.** *L. G. Ghering, Chairman.*

**C-16 on Thermal Insulating Materials.** *W. C. Lewis, Chairman.*

**C-18 on Natural Building Stones.** *L. W. Carrier, Chairman.*

**C-19 on Structural Sandwich Constructions.** *T. P. Pajak, Chairman.*

**C-20 on Acoustical Materials.** *R. N. Hamme, Chairman.*

**C-21 on Ceramic Whitewares and Related Products.** *M. D. Burdick, Chairman.*

**C-22 on Porcelain Enamel.** *W. N. Harrison, Chairman.*

**E-5 on Fire Tests of Materials and Construction.** *W. J. Krefeld, Chairman.*

**E-6 on Methods of Testing Building Constructions.** *R. F. Legget, Chairman.*

Wednesday, June 24 12:00 Noon

### Highway Industry Luncheon

Speaker: Ellis L. Armstrong, Commissioner of Public Roads, Washington, D. C.  
C. A. Hogentogler Award Sanford E. Thompson Award

Wednesday, June 24 2:30 p.m. Twenty-First Session

Held simultaneously with the Twenty-Second Session

### Session on General Testing (Continued)

**A Preliminary Report on Sharp Edge Notch and Smooth Tensile Characteristics of Ultra High Strength Steel Sheet Alloys.** G. B. Espey, M. H. Jones, and W. F. Brown, Jr., *National Aeronautics and Space Administration.*

The sensitivity of ultra-high-strength sheet alloys to very high stress concentrations is evaluated, where the ratio between the sharp-notch tensile strength and the smooth tensile strength is considered to be an indicator of the notch sensitivity. The data reveal the extreme sensitivity of the sharp-edge-notch strength to heat treatments known to produce embrittlement. With the exception of type 301, highly notch-ductile behavior is restricted to strength levels below about 200,000 psi. For 301 notch-ductile behavior extends to strength levels of about 220,000 psi, but only for the longitudinal direction. At a strength level of 250,000 psi, there appears to be no advantage in using the newer highbred steels, the highest notch-strength ratios being obtained for consumable-electrode-melted AMS 6434. At strength levels approaching 300,000 psi, very high notch sensitivity is observed in all cases with 300M being somewhat superior to the other materials.

**Experimental Determination of Energy Release Rate for Notch Bending and Notch Tension, and Applications to Fracturing.** J. D. Lubahn, Jr., *General Electric Co.*

Values of energy-release rate were determined experimentally, as a function of notch depth, for notch bending and notch tension; and by means of fracture tests the critical energy-release rate was determined for two steels. The experimental value of

energy-release rate showed fair to good agreement with analytical values available from the literature depending on notch depth and type of test. In terms of the Griffith-Irwin concept of a critical energy-release rate, the effects of notch depth and specimen size could be accurately predicted if extensive plastic flow did not occur, but correlations of different types of tests by means of this concept were only fair.

**The Tensile Properties of Some Engineering Materials at High Rates of Strain.** A. L. Austin and R. F. Steidel, Jr., *University of California.*

An experimental method to determine the dynamic tensile properties of materials at high rates of strain has been developed. An explosive-impact tensile tester which has provisions for direct measurements of load, impact velocity, and instantaneous changes of diameter as a function of time is used. A charge of gunpowder is used to propel a projectile which is threaded to one end of a standard tensile specimen, the other end being fixed. The fracture strengths, percent reduction in area, and percent elongation for SAE 1018 cold-rolled steel, 6061-T6 aluminum alloy, and C120AV, A110AT, and A 55 titanium alloys have been obtained for strain rates up to 22000/sec. at room temperature. It is concluded that in general the dynamic strength and ductility of these materials increase with increasing strain rate.

**Compression Testing at Constant True Strain Rates.** J. E. Hockett, *University of California.*

A cam plastometer was designed and built to test metal specimens in compression over a range of constant true-strain rates

and over a range of temperatures. Aluminum and uranium specimens were tested at several temperatures and strain rates. From measurements of load and time, true-stress versus true-strain curves were calculated. These curves fit an equation of the form

$$\sigma = A(1 - eBe) + Ce$$

where  $\sigma$  is the true stress,  $e$  is the true strain,  $A$ ,  $B$ , and  $C$  are parameters, and  $e$  is the base of natural logarithms. The use of the cam plastometer, along with statistical methods of curve fitting, provides an accurate means to investigate the effects of temperature and strain-rate on the resistance of metals to compression.

**Effect of Specimen Taper on the Determination of Elongation in the Tensile Test.** E. B. Kula and F. R. Larson, *Watertown Arsenal Laboratories.*

In ASTM standards for round tensile specimens, a 1 per cent difference in diameter is allowed between the center and ends of the gage-length section. This difference is found to lead to differences in local strain of over 30 per cent. The effect on total elongation of the difference in strain between the center and ends of the gage-length section was calculated for two model shapes. Standard ASTM specimens of titanium, iron, and copper were tested and showed measured elongation as much as 15 per cent less than specimens having a uniform diameter throughout the gage-length section. Since the specimen taper is necessary to insure that fracture occurs in the center of the specimen, the differences inherent in determination of elongation from such specimens should be recognized. More widespread use of diameter gages is suggested.

Wednesday, June 24 2:30 p.m. Twenty-Second Session

Held simultaneously with the Twenty-First Session

### Symposium on Practical and Statistical Significance of Tests and Properties of Bituminous Binders

The role of statistics in the testing and research of bituminous materials, particularly as used in highway construction, has not been sufficiently emphasized. With the great national expansion in highway and airfield construction, the amount of testing and research has increased accordingly. Committee D-4 on Road and Paving Materials realizes that the statistical significance should now be brought to the fore and is sponsoring this symposium for that purpose. The papers outlined here discuss precision and evaluation as well as the practical significance of tests on bituminous materials. The fundamental statistical concepts involved in this type of testing are

presented. Reproducibility variation is another factor that will be illustrated. The closing summary will present the possibility for extension and improvement of ASTM tests with the aid of the statistical approach.

**Introduction.** D. F. Fink, *Shell Oil Co.*

**The Evolution of ASTM Tests and Specifications for Asphaltic Materials.** G. Abson, *Chicago Testing Laboratory, Inc.*

This paper traces the origin of most of the tests for asphaltic materials used in highway

construction and maintenance work. It describes briefly the early types of asphaltic materials used in the first hot-mixed pavement mixtures as far back as the last quarter of the 19th century. The first testing methods proposed by Committee D-4 were adopted in 1911. These covered solubility in carbon disulphide for purity, a penetration test for consistency, and a loss-on-heating test for stability. These same tests, with modifications, are still in use today. The ASTM tests are shown to be virtually the bituminous engineer's standards and are invariably referred to by most governmental agencies charged with writing specifications for asphalt paving construction.

**Practical Significance of Tests on Asphalt Cements.** *N. W. McLeod, Imperial Oil, Ltd.*

The primary purpose of tests on asphalt cements is to enable an engineer to select the correct grade of asphalt cement for the particular conditions associated with each pavement project. The practical significance of each of the usual tests for asphalt cements, and their specification limits, is critically reviewed on this basis. Since there are no universally accepted criteria for establishing the precise meaning of the term "quality" as applied to asphalt cements, specification tests provide a guide to the quality of asphalt cements in only a very limited sense.

**Practical Significance of Tests on Liquid Binders.** *C. W. Chaffin, Texas Highway Department.*

Valuable information is revealed by testing the two general groups of liquid asphaltic binders designated as cutbacks and emulsified asphalts. The tests have a practical significance in evaluating a potential binder for its suitability during construction and future performance. An example of the information gained by testing a cutback is the use of the distillation results to predict the curing rate of an RC-2. Also, the laboratory evaluation of emulsified asphalts further illustrates the practical significance of tests in the control and selection of liquid binders. Each of the regular tests offers the laboratory

engineer, chemist, or technologist a practical tool whereby he is able to specify and evaluate a desired property in a particular cutback or emulsion.

**Fundamental Statistical Concepts in Testing.** *P. E. Irick, Highway Research Board.*

Statistical techniques are discussed within a general description of statistical methodology. A simple comparative experiment is used to illustrate the general exposition. Statistics can provide concepts, principles, and rules for obtaining mathematical consistency among three aspects of an experimental investigation: objectives, data acquisition, and data analysis. The concepts of experimental universe and statistical model are fundamental to this purpose. An experimental universe is generated and sampled as a consequence of objectives and data acquisition designs. Objectives are reached by analyzing the data with respect to statistical models that represent associations among universe variables.

**"Reproducibility" as a Variance Measure of an ASTM Test Method.** *F. D. Tuemmler, Shell Development Co.*

A recommendation is made for the use of a single term with a standardized meaning for judging agreement of test results obtained by vendor and buyer when testing samples of a given shipment. A method for computing

this useful term from data obtained from a typical interlaboratory cooperative test program is briefly illustrated. Ways in which this term can be used for comparison of results are described.

**Precision of Present ASTM Tests on Bituminous Paving Binders.** *A. B. Brown, Standard Oil Co. (Indiana).*

Test methods for bituminous paving binders should be adopted only after their precision has been established by cooperative tests and clearly stated in the specification. An analysis of those specifications under D-4 jurisdiction which include references to bituminous binders illustrates the widespread failure of current specifications to observe this rule. Reasons for absence of precision statements are discussed. It is pointed out that, even when included in the specification, precision statements do not follow a uniform pattern, and are frequently ambiguous or poorly adapted to serve their desired purposes. It is recommended that all ASTM methods specifications be required to include a precision statement, that a standard form for such a precision statement be developed, and that a depository for cooperative test data supporting such precision statements be provided by ASTM.

**Summary—Possibilities for Extension and Improvement of ASTM Tests on Bituminous Paving Binders.** *D. F. Fink, Shell Oil Co.*

Wednesday, June 24

4:00 p.m.

Twenty-Third Session

Held simultaneously with the Twenty-Fourth Session

**Committee Report Session**

A-1 on Steel. *J. J. Kanter, Chairman.*

A-5 on Corrosion of Iron and Steel. *H. F. Hormann, Chairman.*

B-2 on Non-Ferrous Metals and Alloys. *B. W. Gonser, Chairman.*

E-3 on Chemical Analysis of Metals. *A. Thomas, Chairman.*

E-4 on Metallography. *L. L. Wyman, Chairman.*

Wednesday, June 24

4:00 p.m.

Twenty-Fourth Session

Held simultaneously with the Twenty-Third Session

**Committee Report Session**

C-7 on Lime. *J. A. Murray, Chairman.*

C-9 on Concrete and Concrete Aggregates. *W. H. Price, Chairman.*

D-1 on Paint, Varnish, Lacquer and Related Products. *W. T. Pearce, Chairman.*

D-3 on Gaseous Fuels. *D. V. Kniebes, Chairman.*

D-5 on Coal and Coke. *O. W. Rees, Chairman.*

D-8 on Bituminous Materials for Roofing, Waterproofing, and Related Building or Industrial Uses. *H. R. Snoke, Chairman.*

D-18 on Soils for Engineering Purposes. *E. J. Kilcawley, Chairman.*

D-25 on Casein and Similar Protein Materials. *H. W. Shader, Chairman.*

D-27 on Electrical Insulating Liquids and Gases. *F. M. Clark, Chairman.*

Wednesday, June 24

4:30 p.m.

Twenty-fifth Session

**Gillett Memorial Lecture**

**The Role of Dislocations in Plastic Deformation (of Metals)**

John C. Fisher, Metallurgy and Ceramics Research Dept., General Electric Co.

This Lecture, established in 1951, is jointly sponsored by ASTM with Battelle Memorial Institute. It commemorates Horace W. Gillett, one of America's leading tech-

nologists and metallurgists and the first Director of Battelle. The Lecture is delivered annually at a meeting of the Society, the first one having been given at the Fiftieth

Anniversary Meeting, June, 1952. The Lecture will cover subjects pertaining to the development, testing, evaluation, and application of metals. [See abstract on p. 7.]

Thursday, June 25

9:30 a.m.

Twenty-Sixth Session

Held simultaneously with the Twenty-Seventh Session

### Session on Cement

**An Approach to the Problem of Evaluation of Plasticity and Workability of Pastes and Mortars.** *A. D. Conrow, Ash Grove Lime and Portland Cement Co.*

Mortars of the same consistency containing materials differing widely in plastic qualities showed different rates of spread when subjected to the flow test. Relation of per cent flow to energy assumed causing flow was found to plot a straight line on log-log coordinates. This relation can be expressed by:

$$F = AE^b$$

where  $F$  = per cent flow,  $E$  = energy assumed to cause flow,  $A$  is a constant related to consistency, and  $b$  an exponent related to rate of deformation. Mortars yielding high values of  $b$  were non-plastic. Mortars with low values of  $b$  were highly plastic. The  $A$  term in the equation indicated per cent flow from application of first unit of energy. Energy causing flow was considered to be the kinetic energy involved in the fall of the specimen through a distance of  $\frac{1}{2}$  in., multiplied by the number of falls.

**Quantitative Determination of the Four Major Phases in Portland Cements by X-ray Analysis.** *S. Brunauer, L. E. Copeland, D. L. Kantro, C. H. Weise, and E. G. Schulz, Portland Cement Assn.*

Two methods have been available for estimating the quantities of the four major

phases (tricalcium silicate, dicalcium silicate, tricalcium aluminate, and calcium aluminoferrite). The potential compound calculation and its various modifications gave not the actual quantities, but the potential quantities that could be present, if certain conditions existed in the kiln and during the cooling of the clinker. The microscopical method gave values too low by missing the smallest particles. Two new methods have been developed for the quantitative determination of the four major phases: one by a combination of X-ray analysis and chemical analysis, the other by X-ray analysis only. The latter is reported in this paper. The results obtained by the two old and two new methods are compared.

**Control of Gypsum in Portland Cement.** *B. Tremper, California Division of Highways.*

Progress in devising simple, practical tests to demonstrate the relationship of the  $SO_2$  content of portland cement to its optimum value are discussed. Test methods have been patterned on the principles set forth by Lerch in 1946: for each cement there is an optimum percentage of  $SO_2$  which produces maximum strength and minimum volume change and which is related to the rate of depletion of gypsum during the early stages of setting and hardening. Emphasis is placed on results of cooperative testing for short-time expansion in water and contraction in air of mortars containing the cement in question and the same cement to

which pulverized gypsum is added in the laboratory to increase the  $SO_2$  content 0.5 per cent.

**Acetate Processed Portland Cement.** *B. E. Keeler, Missouri Portland Cement Co.*

A description is given of the use of acetic acid and salts of acetic acid of greater solubility than calcium acetate to produce free-flowing portland cement. Topics covered are: The history of difficulties caused by the non-free-flowing properties of portland cement, particularly in bulk hopper shipments. The experimental work involved in establishing the effectiveness of acetic acid and the lack of effectiveness of calcium acetate. The evaluation of interferences cited against the potent application. The commercial production of acetate-treated cement and field evaluation of results. The effect of acetic acid or its salts on properties of portland cement other than bulk-flow properties.

**Cement Reference Laboratory.** *J. R. Dine, National Bureau of Standards.*

The significant expansion of activity of the Cement Reference Laboratory into the field of concrete testing has suggested the value of presenting factual information on the entire scope of operations. The functions of the Laboratory are more clearly defined in its present relation to servicing the many cement-testing as well as concrete-testing laboratories throughout the country. Some of the problems in this work are discussed.

Thursday, June 25

9:30 a.m.

Twenty-Seventh Session

Held simultaneously with the Twenty-Sixth Session

### Session on Road and Paving Materials

**The Use of Capillary Viscometers and Fundamental Viscosity Units as a Substitute for the Saybolt Furol Viscometer for Practical Refinery Control of Cut-back Asphalt Production.** *D. V. Levy, F. E. Fassnacht, R. D. Umbach, G. P. Hibler, and D. C. Gagle, Phillips Petroleum Co.*

Experience over 2½ years with the Zeitfuchs cross-arm capillary viscometer as a control instrument in automatic asphalt blend plants demonstrates its practical value in measuring kinematic viscosity of asphalt. Present cut-back asphalt specifications are based on Saybolt Furol values which must necessarily be obtained at several temperatures for the various grades. With several Zeitfuchs capillary tubes, the entire range of cut-back asphalt viscosity requirements can be obtained at a single temperature, 140 F. Adoption of fundamental viscosity units to parallel existing Saybolt Furol units in specifications for cut-

back asphalts will eliminate the need for conversion and stimulate wider use of the more accurate capillary instruments.

**Investigation of a Prototype Aggregate Dryer Using Preplanned Tests.** *M. Lara and C. A. Pagen, Ohio State University.*

Research on the drying rates of bituminous concrete aggregates at the Ohio State University has been facilitated by the use of a small prototype dryer comparable in design to commercially available dryers. Dryer operating conditions such as slope and speed of rotation of the dryer drum, temperature and velocity of the exhaust gases, and type and gradation of aggregate were studied. Also determined were the effects of these variables on the civil-engineering aspects of drying bituminous concrete aggregates, moisture gradients during the drying phenomenon, and physical properties of the listed aggregates. Principles used can be extended to nearly all other aggregate and soil drying

operations. Methods of computing and treating the drying data can be used in predicting the performance of asphalt dryers now in use.

**Change in Density of Asphalt Concrete Cores with Time.** *R. J. Schmidt, California Research Corp.*

An apparent loss in density with time was observed in cores from experimental pavement sections of asphalt concrete. This change was rapid and can account for significant differences in results between laboratories. On other mixes, there is an apparent increase in density. The change, therefore, is not predictable. Some of the change appears to be caused by a slow gain or loss in weight, presumably water. The rest of the change is caused by an apparent increase or decrease in volume of the specimen. This observation offers a basis on which to devise a more reliable procedure for determining the density of asphalt concrete pavements.

Thursday, June 25

11:15 a.m.

Twenty-Eighth Session

### Committee Report Session

D-7 on Wood. *L. J. Markwardt, Chairman.*

D-10 on Shipping Containers. *J. G. Turk, Chairman.*

D-12 on Soaps and Other Detergents. *J. C. Harris, Chairman.*

D-13 on Textile Materials. *B. L. Whittier, Chairman.*

D-14 on Adhesives. *J. E. Rutzler, Jr., Chairman.*

D-15 on Engine Antifreezes. *R. E. Vogel, Chairman.*

D-22 on Methods of Atmospheric Sampling and Analysis. *Leslie Silverman, Chairman.*

D-23 on Cellulose and Cellulose Derivatives. *F. A. Simmonds, Chairman.*

D-26 on Halogenated Organic Solvents. *V. E. Amspacher, Chairman.*



Thursday, June 25

2:00 p.m.

Held simultaneously with the Twenty-ninth Session

### Nuclear Problems Forum

At its meeting on Feb. 4, 1959, in Pittsburgh, the ASTM Special Administrative Committee on Nuclear Problems reviewed the status of the Society's technical committee activities in the area of standardizing requirements for engineering materials used in nuclear reactors. While there is now a great deal of activity in this field throughout the approximately 80 technical committees,

there still remain some areas in which needed work is lacking. The Administrative Committee recognizes that this is probably due to the absence of people on the committees who are familiar with the problems, and is taking steps to correct the situation. A series of forums is planned for the Annual Meeting in Atlantic City and for the Pacific Area National Meeting in San Francisco

this October. All ASTM committees are being invited to send representatives to these forums. The forums are also being publicized to people engaged in nuclear energy projects and attendance from them is urged. In this manner it is hoped to exchange information on standardization work being done in the ASTM committees and on work which should be considered.

Thursday, June 25

2:00 p.m.

Twenty-Ninth Session

### Symposium on Microscopy

The development of new types as well as the greater sophistication of existing microscope designs has led to the necessity of refinements in techniques for using such equipment. The advent of the electron microscope alone has brought a whole host of methods to fit the very exacting requirements for this new tool. All too frequently the individual worker or group has had to initiate methods suitable for the problem at hand. This symposium brings together the many techniques and disciplines that are united by the use of a common instrument, the microscope, be it light or electron.

**Introduction.** F. F. Moorehead, *American Viscose Corp.*

**Measurement with Phase and Interference Microscopes.** O. W. Richards, *American Optical Co.*

Errors of measurement in visual microscopy are mentioned briefly. The phase microscope makes possible measurement of the size of transparent specimens, is useful for counting, and is a good null method for measuring refractive index. Precautions necessary with absorbing specimens are discussed. The interference microscope makes possible measurement of optical path

in transparent and nearly transparent specimens and from the path difference the mass may be calculated for reasonable homogeneous specimens.

**Performance Characteristics of Objectives, Eyepieces and Illuminators for Microscopy.** H. W. Zieler, *Zieler Instrument Co.*

The number of available types of objectives, eyepieces and illuminators for microscopy has increased considerably in recent years, not only for use in new methods and techniques, but also for generally improved performance in well established fields.

Available objective types and eyepiece types will be discussed with recommendation for correct combination.

The selection of the illumination method depends on the optical properties of the object. Performance characteristics of available illuminators in relation to optical properties of objects will be discussed.

**Chemical Microscopy in the Optical Industry.** G. C. Crossmon, *Bausch & Lomb Optical Co.*

Chemical microscopy, as used in the optical industry, requires the use of certain tech-

niques applicable to the manufacture of glass optics. Methods described include procedures for particle size determination of abrasives and polishing materials, also quality control of other purchased and processed products. Although designed for use in the optical industry, these methods using primarily the micro-projector, comparison microscope, and dispersion staining microscopy should be of value in other fields of investigation.

**Study of Ore Minerals in Reflected Light.** E. N. Cameron, *University of Wisconsin.*

The study of ore minerals in reflected light has important functions in mineralogy, economic geology, and mineral dressing; it is the basic technique for determining the mineral components of ores and for investigating the textural arrangements of minerals in various ores. Mineral identification is accomplished largely by qualitative or quantitative determinations of physical properties and of optical properties in polarized light. Increased emphasis is currently being placed on quantitative measurements of properties. Etching and qualitative chemical tests are aids to identification, and x-ray and spectrographic methods are important supplementary techniques.

(Continued in the Thirty-First and Thirty-Third Sessions)

Thursday, June 25

4:30 p.m.

Thirtieth Session

### Committee Report Session

**A-3 on Cast Iron.** T. E. Eagar, *Chairman.*

**B-7 on Light Metals and Alloys, Cast and Wrought.** I. V. Williams, *Chairman.*

**D-17 on Naval Stores.** S. R. Snider, *Chairman.*

**D-20 on Plastics.** F. W. Reinhart, *Chairman.*

**D-24 on Carbon Black.** N. P. Bekema, *Chairman.*

**E-1 on Methods of Testing.** A. C. Weber, *Chairman.*

**E-7 on Nondestructive Testing.** J. H. Bly, *Chairman.*

**Joint Committee on Leather.** J. R. Kanagy, *Chairman.*

Thursday, June 25

8:00 p.m.

Thirty-First Session

Held simultaneously with the Thirty-Second Session

### Symposium on Microscopy (Continued)

**Application of Electron Microscopy in the Petroleum Industry.** H. Alfred, *The Texas Company.*

A summary is given of the progress that has been made in utilizing the electron microscope as a research tool in the petroleum industry. The fields of application discussed include the study of lubricating greases, lubricating oils, liquid fuels, asphaltic materials, particulate materials such as

catalysts and microcrystals, massive surfaces involved in friction and wear, and films and dispersions of macromolecules.

**The Electron Microscope in the Study of Minerals and Ceramics.** J. E. Comer, *Pennsylvania State University.*

Current applications of the electron microscope in the study of minerals and ceramics are presented. Emphasis is placed on the use of improved replica techniques

for examining surfaces of clay minerals, glasses, and ceramic bodies. Several examples are given to show how surface topography can be related to internal structure or to physical or chemical properties of the specimen. The importance of electron diffraction is discussed briefly in relation to recent studies on single crystals to obtain unit-cell parameters, or to obtain structural data which may be correlated with the morphology as determined by electron microscopy.

**Interpretation of Light and Electron Microscopical Observations.** *C. F. Tufts, Sylvania Electric Co.*

The necessity of employing supplementary tools to assist in the interpretation of light and electron microscopical observations is discussed and illustrated. The supple-

**(Thirty-First Session Continued)**

mentary tools considered are X-ray and electron diffraction, and emission and X-ray spectroscopy. The light-microscopy methods include orthoscopic observation in transmitted and reflected light, orthoscopic and conoscopic observation in polarized light, and index of refraction determination. The electron-microscopical methods employ transmission-type electromagnetic optics capable

of producing bright-field and dark-field illumination. Illustrations are taken from recent work dealing with the metallography of tungsten wires, the analysis of thin films, and the analysis of particulate materials such as tungsten powders and alkaline earth carbonates as applied to radio-tube technology.

**(Continued in Thirty-Third Session)**

**Thursday, June 25**

**8:00 p.m.**

**Thirty-Second Session**

Held simultaneously with the Thirty-First Session

**Symposium on Identification of Water Formed Deposits**

**Presentation of the Max Hecht Award.**

**Report of Committee D-19 on Industrial Water.** *Max Hecht, Chairman.*

**Symposium on Identification of Water Formed Deposits**

Since the most recent symposium on this subject in 1947, X-ray diffraction methods have been much improved by the use of the diffractometer, semi-quantitative spectrographic methods have been developed and applied, and a number of newer analytical techniques have been brought to bear on the deposit problem. The present symposium presents the utility of these analytical tools in determining the nature of deposits, starting with a statement of the problem from the standpoint of the water-treatment engineer. Then follow methods of elemental analysis (excluding wet chemical), phase identification, the study of thin corrosion films on steel, and finally the correlation of elemental analysis with phase identification, using the techniques employed for many years by the mineralogist.

**Deposit Identification—The First Step Toward Understanding a Water Problem.** *J. K. Rice, Cyrus Wm. Rice and Co.*

Water-formed deposits of some type are usually associated with almost all water problems that arise in equipment using water. All too often the appearance and "feel" of the deposit are accepted as evidence as to its identity. Such limited observations can lead to conclusions ranging from the ridiculous to the disastrous. Current methods for establishing deposit identity rely on precise physical and chemical tests. Information revealed by such exact examination holds the

key to the means by which the deposit was formed. The sure knowledge of what was formed, and how, is the heart of any solution to a deposit or corrosion problem.

**Application of Emission Spectroscopy to the Analysis of Water-Formed Deposits.** *C. H. Anderson, Babcock & Wilcox Co.*

In this paper the term emission spectroscopy is used in a broad sense to include conventional light-emission spectroscopy, flame photometry, and X-ray fluorescence spectroscopy. Each of these fields is discussed from the point of view of its application to the determination of the elemental composition of water-formed deposits. Advantages, disadvantages of each technique, and recent developments in each field are also briefly reviewed.

**Identification by Instrumental Methods of Chemical Compounds in Water-Formed Deposits.** *C. M. Maddin and R. B. Rosene, Dow Chemical Co.*

Direct identification of chemical compounds in water-formed deposits by petrography, infrared analysis, X-ray diffraction analysis, and differential thermal analysis is discussed. To date, X-ray diffraction methods have proved to be most useful. For this reason, major emphasis is placed on the various factors involved in the successful application of this technique. The present status of petrography and infrared analysis is discussed, including their advantages and limitations. The use of differential thermal analysis in this field is very new. Although it is still too early to assess its ultimate utility in compound identification, the present status is discussed in considerable detail.

**Electron Microscopy and Electron Diffraction Studies of Oxide Films Formed on Iron in Water Vapor and Oxygen Atmospheres.** *E. A. Gulbransen and T. P. Copan, Westinghouse Research Laboratories.*

A study is made of the localized corrosion products formed when pure iron is reacted with water vapor or oxygen. Three types of localized growths are found when iron is reacted at 400 to 500 C. These are: (1) oxide whiskers 200 to 300 Å in diameter, (2) thin blade-shaped oxide platelets about 100 Å thick, and (3) rounded or serrated platelets of oxide about 100 Å thick. The crystal habit of the corrosion product is found to depend on the metallurgy of the metal, its impurities, the stress level, and the nature of the corrosion atmosphere.

**Correlation of Elemental Analysis and Phase Identification as Viewed by a Mineralogist.** *J. V. Smith, Pennsylvania State University.*

Most natural minerals show wide ranges of chemical composition which lead to difficulties in identifying them when several unseparable minerals compose a bulk sample. However, these variations are potentially useful for they reflect the conditions of formation of the mineral (the pressure, temperature, and composition of the environment). The methods and theories developed by mineralogists from studies of both natural and synthetic minerals may be used in the practical problems facing industrial scientists.

**Summary.** *R. K. Scott, Harbison Walker Refractories Co.*

**Friday, June 26**

**9:30 a.m.**

**Thirty-Third Session**

Held simultaneously with the Thirty-Fourth Session

**Symposium on Microscopy (Continued)**

**The Structure of Synthetic Fibers.** *R. G. Scott, E. I. du Pont de Nemours & Co., Inc.*

A brief introduction to the present concept of the solid state of polymers developed from techniques other than microscopy is presented. Present techniques used in fiber microscopy are evaluated. In one technique microdissection is used to study the various portions of a fiber separately. Thin sections are split out of a fiber and studied by optical microscopy, electron microscopy, and electron diffraction. A second method combines etching agents with replication to reveal the micromorphology of the polymer. Techniques, types of information obtained, and limitations en-

countered are discussed, rather than structure problems.

**Microscopical Studies of Failure in Polymers.** *S. B. Newman, National Bureau of Standards.*

Microscopical techniques have been applied to studies of failure mechanisms in plastics. The studies were concerned with crazing, erosion due to wetting and drying, and failure in tension as a function of a number of variables. The light-optical techniques included phase-contrast, micro-interferometric, and schlieren, as well as bright-field. Electron microscopy of surface replicas was also employed. An attempt was made to correlate the observations with mode of failure.

**Microscopical Evaluation of Cotton Finishing Treatments.** *M. L. Rollins, I. V. DeGruy, V. M. Tripp, and A. T. Moore, Southern Regional Research Laboratory.*

Rot-resistant and waterproofed fabrics have long been on the market. More recently flame retardancy, wrinkle resistance, soil repellency, and minimum-care characteristics have been imparted to cotton through chemical finishing. The microscopist, in evaluating such finishes, looks for uniformity of application, homogeneity of distribution in the fabric and the yarn, degree of impregnation of the fiber cell wall, evidence of migration during curing operations, and determines whether additional surface coating has occurred and to what extent the fiber may have been damaged.

Friday, June 26

9:30 a.m.

Thirty-Fourth Session

Held simultaneously with the Thirty-Third Session

### Symposium on Visual Aids for Standardizing and Communicating Product Appearance

This symposium will discuss some of the visual aids available for standardizing and communicating product appearance. While everyone will admit that close specification and control of product appearance is desirable, little attention has been paid to methods of achieving this. The methods to be discussed are not all-inclusive, nor will they be discussed in great detail; rather, a survey of several interesting new developments is planned and the current status of product appearance specification within ASTM will be reviewed. This symposium should stimulate new and original thinking about the problems of product appearance specification.

**Welcome and Introduction.** *J. M. Hemphill, Armstrong Cork Co.*

**Status of ASTM Methods and Standards for Appearance Evaluation.** *I. Nimeroff, National Bureau of Standards.*

A survey of the ASTM appearance methods and standards is presented. Three classifications are distinguished: casual visual inspection, controlled visual inspection, and instrumental measurement. The underlying principles and limitations of these methods are discussed. Instrumental measurement of appearance is by spectral evaluation or spacial evaluation of emitted, transmitted, or reflected light. The measurement of color involves spectral evaluation, while the measurement of gloss, haze, turbidity, and hiding involve spacial evaluation.

ation. It is suggested that ASTM Committee E-12 on Appearance unify, simplify, and generalize future methods for appearance measurement.

**Visual Aids in the Textile Industry.** *J. B. Goldberg, Textile Consultant.*

The use of visual aids in the textile industry for standards or quality control has been practiced for many years. Photographic standards are used to evaluate cotton yarn quality for evenness, for rating water-repellency of fabrics, and the appearance of fuzzy balls or "pills" on textile materials. Photographs have been published to illustrate fabric defects and used by the U. S. Quartermaster Corps to assist inspectors in grading fabrics for military apparel. More recently, photographs and three-dimensional plastic replicas of fabrics with varying degrees of wrinkling have been suggested as a means for judging the performance characteristics of "wash and wear" fabrics and garments.

**Potential Uses of Closed Circuit Television for Product Inspection.** *R. Vendeland, Jerrold Electronics Corp.*

Most of the applications of closed-circuit television in industry have been in sending inaccessible information to remote operators located in a safer or more comfortable vantage point. Exciting possibilities exist for industrial use of closed-circuit television. It can extend man's sight beyond the visible spectrum, enhance man's ability to distin-

guish between areas of low contrast, increase brightness of fluoroscope images, and apply television signals to automated product inspection. Television is compared to human vision and suggestions are offered for applications research.

**Use of Visual Aids in the Grading of Processed Foods.** *F. L. Southerland, U. S. Department of Agriculture.*

More and more vegetables in the United States reach the consumer in canned or frozen form. Growth of the food processing industry has increased the need of the industry and trade for recognized standards of quality. The U. S. Department of Agriculture is developing official grade standards for processed foods. Requirements of each grade with respect to color, texture, maturity, and other quality factors are described in the grade standards. External appearance, including color, form, and external defects is an important factor affecting the grade. Visual aids, including standard color plates, glass color comparators, hand-painted models, photographs, and sketches, have been developed for a number of products. Through a manufacturers' licensing plan these visual aids are being made more widely available.

**Color Photography for Product Specification and Control.** *J. R. Kane, Ansco.*

**Summation.** *G. W. Ingle, Monsanto Chemical Co.*

Friday, June 26

12:30 p.m.

Thirty-Fifth Session

Held simultaneously with the Thirty-Sixth Session

### Committee Report Session

**B-4 on Metallic Materials for Electrical Heating, Electrical Resistance, and Electrical Contacts.** *E. I. Shobert, II, Chairman.*

**B-5 on Copper and Copper Alloys, Cast and Wrought.** *W. H. Jennings, Chairman.*

**C-1 on Cement.** *R. R. Ketchiser, Chairman.*

**C-11 on Gypsum.** *G. W. Josephson, Chairman.*

**C-15 on Manufactured Masonry Units.** *J. W. Whittemore, Chairman.*

**E-2 on Emission Spectroscopy.** *D. L. Fry, Chairman.*

**E-12 on Appearance.** *G. W. Ingle, Chairman.*

**E-13 on Absorption Spectroscopy.** *E. J. Rosenbaum, Chairman.*

Friday, June 26

12:30 p.m.

Thirty-Sixth Session

Held simultaneously with the Thirty-Fifth Session

### Committee Report Session

**D-2 on Petroleum Products and Lubricants.** *H. M. Smith, Chairman.*

**D-4 on Road and Paving Materials.** *A. B. Cornthwaite, Chairman.*

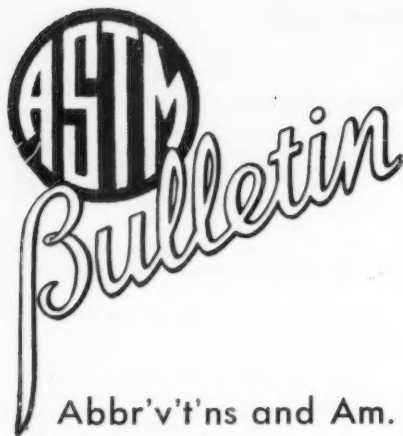
**D-6 on Paper and Paper Products.** *R. H. Carter, Chairman.*

**D-9 on Electrical Insulating Materials.** *H. K. Graves, Chairman.*

**D-11 on Rubber and Rubber-Like Materials.** *Simon Collier, Chairman.*

**D-16 on Industrial Aromatic Hydrocarbons and Related Materials.** *W. E. Sisco, Chairman.*

**E-11 on Quality Control of Materials.** *Simon Collier, Chairman.*



No. 237 April 1959

Nineteen-Sixteen  
Race Street  
Philadelphia 3, Penna.

## Abbr'v't'ns and Am. Soc. Testing Mats.

WE FIND ourselves somewhat embarrassed. Since the days of the New Deal, when Big Government began to emerge from the ruins of the depression, it has been a favorite game for some of us to view with alarm the spawning of governmental "alphabet" agencies. Now it seems we may be in the position of the man who couldn't lick 'em so he had to join 'em.

A recent editorial in *Modern Plastics* stressed the need to simplify and abbreviate many of the jaw-breaking names in the field of plastics. The editorial pointed to the work of our Committee D-20 on Plastics, which has developed and accepted an extensive list of abbreviations. Care is needed in their use, however. *Modern Plastics* strongly recommends that the first time an abbreviation is used in a piece of writing, the completely spelled-out name accompany the abbreviation. But, thereafter, who will not appreciate being able to write PMMA instead of poly(methyl methacrylate).

In connection with the alphabetizing of names, but really aside from the main issue, we have noted a pronounced trend on the part of our officers to stress our initials, ASTM, rather than the full name of the Society. One reason for this, we suspect, is that the word "Testing" can erroneously imply a gross shortening of the activities of the Society. As we emphasize constantly, ASTM has really a much broader interest in materials in general. If testing, in the narrow sense, were our only concern, our research work would be materially lessened, and we would probably not have the hundreds of widely used specifications on which industry bases much of its commerce.

We are just compelled to face it. LRP is going to mean Long Range Planning, and ACS in the appropriate context will be the Administrative Committee on Standards, just as the initials that follow identify your executive secretary.

R. J. P.

## Group Insurance Program for ASTM Members Approved by Board

FOR THE PAST several years considerable thought and study has been given to making available to members and their dependents on a voluntary basis an approved accident and health insurance program.

Details of a specific insurance program for the members of ASTM were explored by our Finance Committee over the past six months. Part of the investigation consisted of sending the proposed program to the Society's insurance counsellors and actuaries, Huggins & Co. The report from Huggins & Co. was eminently satisfactory and the program was approved by our Board of Directors at its meeting of January 20.

The group insurance program contains three basic plans:

1. **The Loss of Time Plan:** With benefits for loss of time due to accident or sickness and accidental death or dismemberment, for ASTM members only.

2. **The Major Hospital-Nurse-Surgical Expense Plan:** With benefits for hospital room and board, miscellaneous hospital expenses, nurse expense while in a hospital and after hospital confinement, and surgery. This plan will be offered with the option of either no-deductible or \$500-deductible coverage. It will be available to members and their spouses and children.

3. **The Senior Hospital-Nurse-Surgical Plan:** With more limited benefits for hospital room and board, miscellaneous hospital expenses, nurse expense while in a hospital, and surgery. This plan is designed primarily for members of the Society over 70 years of age and their spouses.

The key personnel of the Administra-

tor of the program have been successfully administering a similar program for the American Society of Civil Engineers for the past ten years, and a program for The American Society of Mechanical Engineers since June 1958. They also administer a program, started March 1, for the American Society for Quality Control. They assure us that our members will at no time be approached through personal solicitation. Members will soon receive a mailing containing applications and full details of the program.

The program will be underwritten by the Continental Casualty Co. of Chicago, Ill.

There will be a charter enrollment period of 6 months from the date of the first mailing. During that time, if 40 per cent of the members enrolled in any section (or of the entire ASTM membership) apply for coverage, all applications received will be accepted regardless of the physical condition of the member (though members over 60 and impaired risks may be limited as to the amount of coverage they can purchase). If, however, less than 40 per cent of a local section applies, the insurance company will have the privilege of selection on the basis of health (unless 40 per cent of the entire ASTM membership has applied). (Any section with less than 100 members will be combined with another section for qualification purposes only.)

In the meantime, the insurance company has agreed to make the coverage effective for the insurable members after the first 100 acceptable applications from all sections of the Society have been received, so that there will be no undue delay in coverage for those members who are in good health.

The following are some of the outstanding advantages of this group insurance program:

1. The insurance of an individual member cannot be cancelled by the company as long as the individual remains a member of the Society and the program remains in force. The Loss-of-Time Plan, of course, must be dropped when a member retires, and the Loss-of-Time Plan and Major Hospital-Nurse-Surgical Plans can be carried up to the premium due date after a member reaches age 70. The Senior Plan will then be available.

2. The program will be offered to members at rates substantially lower than the cost of similar coverage under individual policies.

3. There will be no physical examination and the application will be an extremely simple one to fill out.

4. Once a certificate of insurance is validly in force, benefits cannot be reduced because of other insurance car-



ried or because an insured performs duties of a more hazardous occupation.

5. The insurance program will provide world-wide coverage and the broadest aviation clause available.

6. If sickness disability begins after the effective date of a certificate of insurance, coverage is provided, regardless of the date of origin of the ailment. Once a certificate is validly in force, it cannot be changed to eliminate coverage of this ailment.

7. The Major Hospital-Nurse-Surgical Plan will be available with the option of \$500-deductible, so as to eliminate duplication of benefits with a basic hospital expense plan a member may already carry. However, unless other

coverage is of a catastrophic nature, this plan may be superimposed on a basic plan, even though there may be some duplication of coverage.

8. Benefits from the Society's insurance program will be paid regardless of any other insurance which the member may carry.

The success of the program will depend upon the interest and active support of our membership. The Society is *not* sponsoring this program, and no expense will be incurred by the Society in developing or continuing the program if it becomes effective. Nevertheless, the Board of Directors feels that many members may consider this a worthwhile project and it is urged that each member give the matter consideration.

## Society Votes to Enlarge ASTM Board of Directors

AT A SPECIAL meeting held at ASTM headquarters, December 17, 1958, the Society voted to amend Section 6 of its Charter to increase the membership of the Board of Directors from fifteen to eighteen. All members present voted for adoption of the amendment. Proxy votes included 3570 votes in favor of the amendment and 32 negative. Chairman of the meeting was Harry M. Hancock, Atlantic Refining Co., Philadelphia, Pa.

The increase in membership of the Board, which is in line with the growth of the Society in recent years, will give the Board the benefit of a more varied background and a broader perspective.

## Units of Measurement—Babel?

*Myself when young did eagerly frequent Doctor and Saint, and heard great Argument  
About it and about: but evermore Came out by the same Door as I went.*

—Rubáiyát

THOSE ATTENDING the Symposium on National and International Aspects of Systems of Units sponsored by the American Association for the Advancement of Science last December in Washington were no doubt helpfully informed, but at the same time they must have come away with mixed emotions. It was made quite clear at the symposium that many of our units of measurement have developed rather haphazardly and, further, that there exists today no organized effort to bring order out of the chaos.

It must first be admitted that, despite severe criticism of our hodgepodge of Anglo-American and metric systems, science and technology do manage to muddle through. Nevertheless there are many, such as those in the field of nuclear engineering, who insist that we should adopt a unified system of units.

Neither in this symposium (ably developed by Carl F. Kaysan, Columbia University) nor in the AAAS special committee appointed to draft recommendations and resolutions on the metric system did there develop any crusade for the adoption of a unified system. To be sure, proponents of metric units stated their position, and so did those who strongly support use of our Anglo-American units—especially the decimalization of the inch. The latter trend, it may be noted, seems to be increasing.

Unquestionably those working largely in the Anglo-American system and wishing to do business with metric countries, including Latin America, are handicapped—although there were statements by leading manufacturers that for export business metric units can be used and conversion problems are not really serious.

In an excellent paper developed as an ASTM contribution by Messrs. Moran, Ruh, and Thompson, who head metalware, glassware, and thermometer subcommittees in the Society, the authors pointed out areas where simplification might lessen some problems considerably. This paper, presented by Dr. Thompson at the meeting, will be published by AAAS as part of the symposium, and perhaps also separately by ASTM.

A British committee is making a study to determine the cost in different industries of a clean conversion to the metric system. In some areas, the cost would seem to be prohibitive. This was confirmed strongly in papers by responsible representatives of American industry.

General agreement existed on at least one point, namely, that there is an advantage in many areas to the practice of showing measurements in both systems of units. This has already been done in some ASTM standards, and further thought will be given to it in ASTM.

## Third Pacific Area National Meeting San Francisco October 11-16

One scientific authority suggested a paraphrase of a Lincoln statement to the effect that our country could not long survive half metric and half Anglo-American. On the other hand, a thought-provoking review, "Can We Live in Babel?" by Ralph A. Sherman, assistant director, Battelle Memorial Institute, suggested that the adoption of the metric system alone would probably not guarantee a single system. He noted that the Anglo-American system is used in many areas in Europe and that the metric system is widely used in the United States—for example in the field of chemistry. Mr. Sherman said there is probably much less chaos in units of measurement in the United States than in many other countries, and he concluded that while we do "live in Babel" and to some extent we shall probably always do so, with care and respect for others we shall be able to continue to do so without undue hardship.

# NEW ASTM PUBLICATIONS

## Look Folks—No Phantoms!

IN ILLUSTRATIONS in recent issues of the BULLETIN, we have followed the whimsy of reporting progress on the printing of the *Book of Standards* by showing the completed Parts dark and keeping those that were

still incomplete a light gray. We are happy now to be able to show them all as having been completed. Books have been distributed to members in accordance with the requests that are on file. A listing of the ten Parts, together



Completed—A Mammoth Publication Job!

Vital statistics on the ten Parts of the 1958 Book of ASTM Standards: Number of standards—2658. Number of pages—14,405. Number of copies in this edition—164,000. Paper used—12 carloads, or 400,000 lb. High-speed press time—4150 hr, or nearly 2 years of 8-hr days for one press. Sewing and binding materials—750 miles of thread, 58,800 lb of binders board, 19,250 yd of cloth for covers, 6970 lb of lining for covers, 2,490,000 sq in. (0.4 acre) of gold leaf. Voluntary contribution of time by technical committee members—untold thousands of man hours.

with the final sizes and editions, is given in the listing below.

Much could be written on what these books mean intrinsically and the amount of effort that has gone into the many standards that are included. The thousands upon thousands of man hours of work contributed by the members of our technical committees represents a purely voluntary effort. But this work has been entered into only in the conviction that the results are well worth the effort and can be remunerative in many ways. The full benefit can be realized only if the standards are put to use.

Statistics with respect to this book are secondary, but interesting in themselves, as set forth in the accompanying illustration caption. Of special interest is the fact that 54 per cent of the standards in the 1958 edition have year dates later than 1955. The breakdown according to the individual Parts is given in the following table.

The people all over the world who use this most valuable reference now have the opportunity of bringing it up to date to reflect the great volume of new thought and research that has played such a great part in its preparation.

### Minimum Invoice Amount Set

Owing to rising production costs, it will be necessary for us to fix a minimum invoice amount of \$1.00 for all ASTM publications and reprints effective April 15, 1959. Since our price schedule in general remains unchanged, this will affect only items normally priced at less than \$1.00.

Part	Title	Number of Pages	Edition	Number of Standards	Standards Issued or Revised in 1956, 1957, or 1958	
					Number	Per Cent
1	Ferrous Metals (Specifications).....	1624	23,000 (partial)	291	193	66
2	Non-Ferrous Metals (Specifications), Electronic Materials.....	1390	21,000	251	166	66
3	Methods of Testing Metals (Except Chemical Analysis).....	994	20,000	121	54	45
4	Cement, Concrete, Mortars, Road Materials, Waterproofing, Soils.....	1475	18,500	339	174	52
5	Masonry Products, Ceramics, Thermal Insulation, Acoustical Materials, Sandwich and Building Constructions, Fire Tests.....	1144	15,500	242	123	51
6	Wood, Paper, Adhesives, Shipping Containers, Cellulose, Leather.....	1040	12,000	219	84	38
7	Petroleum Products, Lubricants, Tank Measurements, Engine Tests.....	1512	13,000	211	122	58
8	Paint, Naval Stores, Aromatic Hydrocarbons, Coal and Coke, Gaseous Fuels, Engine Antifreezes.....	1632	11,500	364	155	43
9	Plastics, Electrical Insulation, Rubber, Carbon Black.....	2060	16,500	351	211	60
10	Textiles, Soap, Water, Atmospheric Analysis, Wax Polishes.....	1534	13,000	269	150	56
	Total	14,405	164,000	2658	1432	54

## 1958 Proceedings Available Soon

AS THIS BULLETIN goes to press, all editorial work on the ASTM *Proceedings*, Volume 58, 1958, has been completed and there remains only the printing of a few of the forms and the binding before the book is mailed to members who have requested it. It is expected that the volumes will be in the mail about the first of May.

The 1425-page volume recording the technical accomplishments of the year includes reports and papers, together with discussion offered to the society during the year and accepted for the *Proceedings*. The volume includes the Summary of Proceedings of the ASTM 61st Annual Meeting, listing by title and author the programs for each session. A Summary of the Proceedings at the special meeting for charter revision, held on Dec. 17, 1958, is also included.

The president's annual address by Richard T. Kropf is entitled "A Continuing and Vital Challenge." Drawing mental pictures from the dawn of history to the present and into the future, Mr. Kropf asks who would exchange the problems and uncertainties about which so many worry today for the conditions which prevailed at the time of the cave man who seldom knew where his next meal was coming from, and if he did know he was not certain whether he would live to eat it. From earliest times man has relied for his survival and development upon the selection and use of whatever materials he could obtain to provide for his welfare. The history and progress of civilization are inseparable from materials, and an important role has been played by ASTM members through their Society. Survival is still a problem although not so immediate as for the cave man, and the knowledge and use of materials continue as important factors. In looking to the future Mr. Kropf expressed his enthusiasm and confidence in ASTM and its ability to meet every great challenge on every new horizon.

The annual report of the Board of Directors highlights matters administrative, technical, and financial for the benefit of members. Included are records of all meetings held by the Society and its districts, information on membership gains, publications, honors and awards, and other matters of interest. There are 74 reports of technical committees which together with appendices provide a wealth of useful information as do the 51 technical papers and discussions on a wide variety of subjects pertaining to research and testing materials.

In addition to the papers and reports embodied in the *Proceedings*, there are listed all symposia and other special sessions published separately as Special Technical Publications and all papers published in the ASTM BULLETIN.

Although the Society's publications program has expanded greatly in recent years with an ever-increasing number of Special Technical Publications, the *Proceedings* remains the repository of factual information and a record of the Society's work. An important adjunct is a Subject and Author Index to all papers published in any form by the Society in 1958.

It should be emphasized that in addition to the reports and technical papers many of which have been given at the national meetings and some of which have been preprinted, the *Proceedings* contain much discussion not previously published.

Copies of the *Proceedings* may be obtained from the American Society for Testing Materials at \$12.00.

### On the Making of an Index

WITH THE appearance of the 1958 Book of ASTM Standards, the Combined Index to ASTM Standards has been thoroughly overhauled to serve as an auxiliary to the Book. This Index lists not only the standards in the ten Parts of the Book, but those in the Methods of Chemical Analysis as well, and also some material in the compilations of standards and other publications.

The Index is intended primarily as a ready reference to show whether a standard has been issued on a given subject and where it may be found. It does not cover obscure material internal to a standard. One of its more important

### Manual for Rating Aviation Fuels by Supercharge and Aviation Methods

THIS VOLUME contains the methods for testing the knock characteristics of aviation fuels by the supercharge and aviation methods. It supersedes these sections previously covered in the 1952 ASTM Manual of Engine Test Methods for Rating Fuels and brings the information up to date at the same time.

This book contains two methods: Supercharge Method D 909 and Aviation Method D 614. Each method is amplified by six extensive appendices. The first appendix relates to apparatus, the second to reference materials and blending accessories, the third to operation, the fourth to maintenance, the fifth to installation and assembly, and the sixth to building and utility requirements.

*Manual for Rating Aviation Fuels by Supercharge and Aviation Methods*, 332 pages, cloth cover, price \$16.00, to members \$13.50.

features is a listing of the standards in numeric sequence, which is particularly useful for those wishing to locate a standard and the serial number of which is known. This list also includes references to any tentative revisions of standards that may be pending.

The Index is a title listing rather than a complete index. While considerable care has been taken in its preparation, it unquestionably could be improved. Everyone has his own approach to using an index, and often he does not find things where he expects to. If any user has suggestions for improvement, we should appreciate having our attention called to any shortcomings.

### Papers to Appear in Future Issues of the ASTM BULLETIN

Determination of Ignition Loss in Portland Blast-Furnace-Slag Cements—*Bernhard Chaiken, Bureau of Public Roads.*

Shear Effects in F. R. P. Laminates—*R. E. Chambers and F. J. McGarry, Massachusetts Institute of Technology.*

Failure Mechanisms in Fiberglass-Reinforced Plastics—*M. B. Desai and F. J. McGarry, Massachusetts Institute of Technology.*

Further Development and Use of the Armstrong Sandpaper Abrasion Machine—*F. M. Gavan, Armstrong Cork Co.*

Effect of Specimen Taper on the Determination of Elongation in the Tensile Test—*E. B. Kula and F. R. Larson, Watertown Arsenal Laboratories.*

Low-Temperature Tensile Properties of Copper and Four Copper Alloys—*R. M. McClintock, D. A. Van Gundy, and R. H. Kropschot, National Bureau of Standards.*

The Temperature Dependence of Electric Resistivity of Laminated Thermoset Materials—*T. D. Schlach, Bell Telephone Laboratories, Inc.*

Measurement of Surface Moisture—Second Progress Report—*P. J. Sereda, National Research Council of Canada*



## Wood, Wood-Base Materials, and Wood Preservatives

### Compilation of Standards, D-7

DESPITE THE regular development of new materials, wood continues to be one of the most popular and versatile materials of construction. Its adaptability for many uses and its ease of handling are still unsurpassed. The unabated demand for wood has been reflected in the activities of Committee D-7 on Wood, which is responsible for the standards in this compilation. It is interesting to note the new developments in the use of wood as a base for such materials as plywood, building board, and particle board. New standards have been developed or are in process for such materials.

This compilation, superseding the 1954 edition, contains 69 standards of which 37 have been revised, have changed status, or are new. Wood technologists and engineers will find methods for evaluating mechanical and physical properties, methods of chemical analysis, fire tests, and general methods of test included.

In addition to wood, the compilation covers veneers, plywood, fiber building boards, timber, and wood preservatives. In addition to methods of test, the volume contains definitions of terms and specifications for various related materials.

*ASTM Standards on Wood, Wood-Base Materials, and Wood Preservatives*, approx. 452 pages, paper cover, price \$5.50, to members \$4.40.

### Symposium on Paper and Paper Products

SINCE World War II, many new types of paper have been developed. In a product where cellulose has held dominance for generations as the principal fibrous component, inorganic and synthetic organic fibers have become commercial realities. This has been made possible by the development of new agents for bonding the fibers. New chemical modifications of the cellulose fibers have also been developed. In addition, papermakers have adopted new plastics for coating and impregnation. Mechanical modifications in the paper sheet have been developed.

As in all product development, testing has played a necessary and important role in the success of these new accomplishments. For evaluating the special properties of the new products it is often necessary to develop new methods of test or to adapt existing methods.

This symposium acquaints the paper technologist and consumer with some of the new developments in paper and

with the methodology which has been evolved. It is hoped that the new testing techniques may lead to a fresh approach in the development of improved methods for conventional papers. The contents are:

Introduction—H. A. Birdsall.

Some Historical Developments in Paper Testing—W. R. Willets and F. R. Marchetti.

Testing of Synthetic Fiber Papers—F. H. Koontz and J. K. Owens.

Nonwoven Fabrics and Synthetic Fiber Papers: Technology and End Uses—J. T. Taylor and P. J. McLaughlin.

New Developments in the Internal Bonding of Paper—K. W. Britt.

A New Cotton Paper Furnish—Properties, Applications, Identification—J. A. Harpham.

Clupak Paper—A New Type of High Stretch Paper—Its Manufacture and Performance—R. J. Diaz.

Relative Humidity Measurements in Package Materials Testing—B. H. Schrier and P. K. Wolper.

*STP 241*, 80 pages, hard cover, price \$2.75, to members \$2.20.

### 1958 Report of Committee D-9 to Supplement 1957 Compilation

IN LIEU of preparing an entirely new edition of the *Compilation of Standards Relating to Electrical Insulating Materials*, Committee D-9 has reprinted its annual report, which will be supplied as a supplement to the 1957 compilation. The report sets forth the recommendations which were acted upon at the 1958 Annual Meeting, and includes several proposed methods as appendices. Copies of this report will be furnished with all future orders for the compilation. Present holders of the compilation can also bring them up to date by ordering copies of the report. *Report of Committee D-9 on Electrical Insulating Materials*; 49 pages, self-cover, price 40 cents.

## 2 dates TO REMEMBER

June 21-26, 1959  
Atlantic City, N. J.  
62nd Annual Meeting

Oct. 11-16, 1959  
San Francisco, Calif.  
3rd Pacific Area National Meeting



## Businessman Abroad

AS AMERICAN businessmen, it is not enough for us to go abroad simply to sell merchandise or exploit natural resources. We must have real respect and appreciation for the point-of-view and the way of life of friendly peoples. To my way of thinking, America stands for much more than what we call "our way of life" or even that much-maligned dynamo that makes our system run called "capitalism." America really stands for the freedom of the individual, and this is a freedom that can be attained and enjoyed in countries other than our own.

American businessmen... have a great opportunity to help improve the standing and reputation of our nation abroad. As we travel and carry on trade among other peoples and other countries, we should do more than conduct ourselves simply as good businessmen—we must become dedicated individuals, selling not only ourselves but our country as well. Each of us must resolve to do the biggest selling job of his life, and do it now!

This brings us—a country still young in the eyes of many older nations—to the crux of our problems in the future. The challenge that stands before us today cannot be met in terms of dollars, or in terms of material wealth, or in terms of how many widgets we can manufacture. The vital questions which face the American people today are these:

- Can we forego the luxury of playing domestic politics when our foreign interests—paramount to our survival—are at stake?

- Can we learn to understand and respect—or at least to tolerate—the patriotic aspirations of friendly foreign peoples?

- Can we put aside selfish interests and thus maintain favorable trade balances vital to our continuing prosperity?

- And finally can we sell abroad—and I mean *really* sell—our way of life in competition with communism?

*I say we can.*

—Augustus C. Long,  
Chairman of the board,  
The Texas Company

From an address given at the Sales Executive Club of New York Oil Progress Week Luncheon, New York City, October 14, 1958.



## Science Fairs

by Archibald T. McPherson<sup>1</sup>

IN MORE than half a million homes throughout the United States The Science Fair is a topic of consuming interest in family conversation at this time of the year. It may be the fair to be held soon, the fair that has just been concluded, or perhaps next year's fair for which a new project is already being planned. The phenomenal growth of the science-fair movement is a clear demonstration of the importance of learning by doing. The exhibits at every fair show that many young people can acquire a knowledge of scientific principles and a mastery of techniques and skills far beyond the level of present-day science teaching in secondary schools. The early development of science talent is further shown by surveys of professional scientists which indicate that a considerable percentage of them decided upon their future careers at the junior high school age. Under the stimulus of science fairs, the interests of greater numbers of gifted young people are being turned to careers in science, mathematics, and engineering.

Many ASTM members are actively concerned with science fairs, both as parents and as leaders in their communities. By reason of their background in science they are often called upon for guidance in the selection of projects. Some gifted and well-read students know at once what they want to work on and have their own ideas as to how they wish to plan and develop their projects. The large majority of young people, however, profit by guidance and discreet assistance—not dictation—in planning and carrying out their first original investigations.

To afford the maximum challenge, a science project should be in a field of current scientific interest and should provide an opportunity for pioneering and original discovery to the extent that the results could not have been fully anticipated in advance by the student as would be the case with a textbook experiment. At the same time, the facilities, materials, and equipment needed should be within the resources of the household, school, or community, and the work should offer reasonable prospect of success within the allotted time.

<sup>1</sup> Associate Director, National Bureau of Standards, Washington 25, D. C.

ASTM members need only to look with imagination and a fresh point of view at the materials with which they have daily concern to propose many stimulating problems. Every school boy and girl now knows that the major limitations on the performance of rockets, satellites, and manned space vehicles are those imposed by the properties of materials. The same is equally true of the less glamorous problems of modern technology. Studies of properties of materials afford almost endless possibilities for investigations which will lead to results that will be fresh and surprising to the layman, even though they may be known to the research specialist. Furthermore, even the most familiar materials have properties that have been passed by in industrial research because they are regarded as being of only academic interest.

Since one large and long-standing ASTM committee deals with rubber, some illustrations will be cited dealing with properties of rubber. The simple bouncing of a rubber ball yields some results that are striking when the height of rebound is measured as a function of temperature of the ball and the type of rubber over the range from the steam point to the temperature of dry ice. Even more striking is the contraction of stretched rubber on heating, such that a stretched rubber band can be made to lift a weight of several pounds. On the

experimental side, this phenomenon can be demonstrated quite simply or it can be made the basis of a heat engine or a refrigerator with nearly any desired degree of sophistication. The explanation takes one into the fascinating theory of large molecules. In the field of little-known properties, mention may be made of the electroelastic behavior of rubber, whereby relatively large static charges can be developed by stretching or compression, or, conversely, rubber may be deformed by the application of an electrical potential.

The properties of rubber have almost endless applications in other fields. Thus through work in ASTM and elsewhere the budding young meteorologist who wishes to relate ozone concentration in the atmosphere to changes in the weather needs, for estimating the ozone in parts per hundred million, only some strips of rubber having a glass-smooth surface, some paper clips, and a hand lens.

An imaginative approach to the properties of materials will provide many stimulating and original problems for science fairs. Even more important will be the lifetime interest that numbers of young people will acquire in this basic field, and in addition, all who undertake the work will benefit greatly from learning to make careful, purposeful measurements.

## ASTM Standards Approved As American Standard by American Standards Association

### PLASTICS

(Approved Feb. 12, 1959)

Test for Acetone Extraction of Phenolic Molded or Laminated Products (ASTM D 494 - 46; ASA K65.12-1959)

Test for Index of Refraction of Transparent Organic Plastics (ASTM D 542 - 50; ASA K65.7-1959)

Test for Deformation of Plastics Under Load (ASTM D 621 - 51; ASA K65.4-1959)

Spec. for Molds for Test Specimens of Plastic Molding Materials (ASTM D 647 - 57; ASA K66.1-1959)

Test for Compressive Properties of Rigid Plastics (ASTM D 695 - 54; ASA K65.1-1959)

Spec. for Cellulose Nitrate (Pyroxylin) Plastic Sheets, Rods, and Tubes (ASTM D 701 - 49; ASA K64.3-1959)

Test for Rockwell Hardness of Plastics and Electrical Insulating Materials (ASTM D 785 - 51; ASA K65.3-1959)

Spec. for Cellulose Acetate Plastic Sheets (ASTM D 786 - 49; ASA K64.2-1959)

Spec. for Ethyl Cellulose Molding Compounds (ASTM D 787 - 55; ASA K64.1-1959)

Test for Luminous Reflectance, Transmittance, and Color of Materials (ASTM D 791 - 54; ASA K65.6-1959)

Test for Specific Gravity of Plastics (ASTM D 792 - 50; ASA K65.8-1959)

Test for Ammonia in Phenol-Formaldehyde Molded Materials (ASTM D 834 - 57; ASA K65.11-1959)

Method of Measuring Shrinkage from Mold Dimensions of Molded Plastics (ASTM D 955 - 51; ASA K66.3-1959)

Test for Haze and Luminous Transmittance of Transparent Plastics (ASTM D 1003 - 52; ASA K65.5-1959)

Test for Stiffness Properties of Nonrigid Plastics as a Function of Temperature by Means of a Torsional Test (ASTM D 1043 - 51; ASA K65.2-1959)

Test for Apparent Density and Bulk Factor of Granular Thermoplastic Molding Powder (ASTM D 1182 - 54; ASA K66.2-1959)

Test for Dilute Solution Viscosity of Vinyl Chloride Polymers (ASTM D 1243 - 58 T; ASA K65.10-1959)

Test for Total Chlorine in Vinyl Chloride Polymers and Copolymers (ASTM D 1303 - 55; ASA K65.9-1959)

## District Activities



### Membership Awards Presented to Texas Students

President K. B. Woods awarded memberships in ASTM to two outstanding engineering students at the Southwest District Meeting held March 2 at Texas A & M College. In left photograph, recipient John W. Rinard is congratulated by President Woods (left) and ASTM Executive Secretary R. J. Painter. At right, recipient Henry Slagle receives his award from President Woods. To the right of Mr. Slagle is Fred J. Bensen, dean of engineering, Texas A & M.

### Coming District Meetings

Date	District	Speaker	Place
April 18	New England	A. A. Bates	Hanover, N. H.
April 23	New York	Raymond Ewell	New York City
April 23	New York	(Metals program)	Utica, N. Y.
April 29	Detroit	K. B. Woods	Detroit
April 30	Pittsburgh	K. B. Woods	Pittsburgh

### Schedule of ASTM Meetings

This gives the latest information available at ASTM Headquarters. Direct mail notices of all district and committee meetings customarily distributed by the officers of the respective groups should be the final source of information on dates and location of meetings. This schedule does not attempt to list all meetings of smaller sections and subgroups.

Date	Group	Place
May 18-22	Committee E-14 on Mass Spectrometry	Los Angeles, Calif. (Statler)
May 17, 18	Committee C-21 on Ceramic Whitewares and Related Products	Chicago, Ill. (Palmer House)
May 20	Committee C-14 on Glass and Glass Products	Chicago, Ill. (Palmer House)
May 21	Committee D-21 on Wax Polishes and Related Materials	Chicago, Ill.
June 21-26	Annual Meeting	Atlantic City, N. J. (Chalfonte-Haddon Hall)
Sept. 22-24	Committee B-5 on Copper and Copper Alloys, Cast and Wrought	Washington, D. C. (Sheraton Park)
Sept. 29-30	Committee C-22 on Porcelain Enamels	Columbus, Ohio
Oct. 7-8	Committee C-8 on Refractories	Bedford, Pa.
Oct. 11-16	Third Pacific Area National Meeting	San Francisco, Calif. (Sheraton-Palace)
Oct. 13-16	Committee D-13 on Textile Materials	New York, N. Y. (Sheraton-McAlpin)
Oct. 15-16	Committee C-3 on Chemical Resistant Mortars	Glens Falls, N. Y. (Queensbury Hotel)

### Students to Attend Conference on Uses of Atom

TO RECOGNIZE and foster ability and interest in science, the First National Youth Conference on the Atom will be held in **Atlantic City, April 30 and May 1**. Some 500 of the Nation's ablest high school students and their science teachers will hear talks by prominent men in the field of peaceful uses of nuclear energy, and will examine exhibits by more than 25 organizations.

Students will be selected from winners of local Science Fairs and also on the basis of special written examinations, essay contests, and demonstrated interest in science, especially physics.

Sponsored by some 60 electric utility companies, the conference is being supported by the American Association for the Advancement of Science, Atomic Industrial Forum, Future Scientists of America Foundation, National Science Foundation, National Science Teachers Assn., and Science Clubs of America.

An indication of the importance that is attached to this effort to interest students in science is given by the list of outstanding men who will address the conference: John A. McCone, chairman, Atomic Energy Commission; Norman C. Hilberry, director, Argonne National Laboratory; Charles E. Robbins, executive manager, Atomic Industrial Forum; Cyril Comar, director, Laboratory of Radiation Biology, Cornell University; John Laughlin, chief, Division of Physics, Sloan-Kettering Institute for Cancer Research; Francis K. McCune, vice-president, General Electric Co., and Charles H. Weaver, vice-president, Westinghouse Electric Corp.

### Weights and Measures Conference Set for June

THE 44TH NATIONAL Conference on Weights and Measures, sponsored by the National Bureau of Standards, will be held in **Washington, D. C., June 8 to 12, 1959**, with headquarters at the Sheraton-Park Hotel. Topics to be discussed include: functions of the several Federal Government agencies concerned with weights and measures, consumer interests, legal problems at the State level, methods of cooperative enforcement, and weights and measures administration. Tentative programs may be obtained from W. S. Bussey, National Bureau of Standards.

# Railroads Report on Research

MANY BRANCHES of engineering knowledge are called upon in the research activities outlined in the 1958 Annual Report of the Association of American Railroads. Projects range from timber trestles to weed killers; from prestressed concrete ties to stretchable paper bags.

AAR research activities are concentrated in its Research Center located in the Technology Center development of the Illinois Institute of Technology in Chicago. The Annual Report is available from the Association's Research Center, 3140 S. Federal St., Chicago 16, Ill. The report is in four sections: Engineering Research Division, Mechanical Research Division, Container and Loading Research and Development Laboratory, and Sanitation Research and Development. The first three sections are covered in the following summary.

## Engineering Division Research

Engineering Division Research deals with the construction and maintenance of roadway, timber trestles, steel and concrete bridges, track, ties, rails, and accessories. Much of this research develops new and better methods, designs, and specifications for the materials used to maintain this vast facility.

Properties of soils are studied in a well-equipped laboratory in the Research Center. The use of lignin liquor in soil mixtures to prevent frost heave is under study, as is the use of asphalt and waste oil to control wind erosion and drifting in sand areas.

Open-hearth slag, proposed for use as ballast, has been extensively tested and proved satisfactory under pulsating loads. For use with electrified rails, however, iron elements would have to be removed, probably by electromagnets during screening and crushing.

A cooperative program with the Asphalt Institute was established to determine the benefits of asphalt treatment of roadbed ballast. Specially equipped cars for this treatment have been built.

Chemicals for clearing track areas of vegetation are still the subject of much study. Although some effective chemicals have been found, there appears to be no cure-all. There is a need, even after most weeds have been killed, for spot control of a number of troublesome perennials that often infest the roadbed after their competition has been removed.

The cost of maintaining the cross ties in the tracks is the largest item of ex-

pense in the maintenance of way and structures. Service life of a creosote-treated wood tie is nearly 30 years, its life being limited primarily by splitting, checking, and abrasion from the tie plates. Only a very few ties are removed because of decay. Several types of prestressed concrete ties are being studied. Service experience with low-alloy, copper-bearing steel tie plates shows increased resistance to corrosive attack, especially in an industrial atmosphere. Accelerated laboratory tests, however, did not show any appreciable benefits.

Rail detector cars have located the first few transverse progressive fractures in acetylene pressure butt welds. This type of failure was fairly common in hand welds. Research effort is toward miniaturized test equipment that can be installed in a road-rail type light truck.

One half of all rail failures are of the shelling type. During 1958, service installations of fully heat-treated rails, flame-hardened rails, chromium-vanadium rails, and high-silicon rails were inspected. All showed increased resistance to shelling failures as compared with standard carbon steel rail.

A continuing study is the examination of a group of bridges showing concrete deterioration, attributed to cement-aggregate reaction. Service data are being gathered from a group of prestressed concrete bridges, one of which has the longest prestressed concrete railway girders in the United States. These data help to develop rational impact equations for similar bridges. The Research Center Staff has been working with such other groups as the Highway Research Board, the American Concrete Institute, the Reinforced Concrete Research Council, and ASTM.

Many tests are under way to determine the useful service life of wood members in bridges and trestles. Laminated timber girders, fire-retardant coatings, and termite controls are also being studied.

## Mechanical Division Research

Mechanical Division Research investigates the suitability of materials and equipment used in rolling stock and engines. This Division supervises certification tests and prepares formal certificates of approval for new equipment offered by manufacturers. This equipment must meet specific requirements of design, material, strength,

serviceability, and in some cases interchangeability with similar equipment produced by other manufacturers.

Exhaustive tests of journal-box lubricants, some containing additives such as molybdenum, are under way. Procedures have been developed for evaluating rapidly the system of babbitt on steel. Tests of aluminum-backed bearings with babbitt linings of standard dimensions and physical specifications have not proved too successful. However, these tests indicate that a thinner lining extending over the end of the bearing contacting the journal collar shows promise.

The Division now has two full-scale axle fatigue machines. Investigations of broken axle journals and methods of nondestructive inspection of axles have been completed. A study of stresses in diesel locomotive wheels is under way in cooperation with the Technical Committee on Wrought Steel Wheels and Axles of the American Iron and Steel Institute, and the Electromotive Division of the General Motors Corp.

Performance testing of diesel locomotive fuel filter elements has been expanded and accelerated during the past year, and a program is under way for the study of fuels and lubricants for diesel locomotives engines.

This Division is active in such organizations as The American Society of Mechanical Engineers, ASTM, American Standards Assn., National Association of Corrosion Engineers, and the American Society of Heating, Refrigerating, and Air-Conditioning Engineers.

## Container and Loading Research and Development Laboratories

This laboratory, one of the best equipped of its kind in the country, is a service organization to the railroads. Its aim is to develop economical methods of packaging and loading so as to assure safe delivery of merchandise shipped by rail. The loads to which a unit is subjected during handling and transit are studied so that they can be minimized by developing new loading techniques.

A new rubber unit for securing the modern curved automotive windshield has been developed and submitted to the automobile industry. This unit, with a stretch of about 6 to 8 in., can be used for a great many sizes of glass and will conform to many shapes and curvatures.

New wrapping materials for cotton bales are being evaluated cooperatively with the National Cotton Council of America as a protective against dirt and contamination during shipment.



(Continued from page 31)

When nails, used to hold the lining boards to the inside walls of a box car, loosen and protrude from the board, merchandise in the car can be seriously damaged. The relative holding power of various new types of nails is the subject of a long-range test program.

A new stretchable kraft paper that

combines light weight and pliability with superior strength has reduced the number of burst bags in shipments of bulk items such as cement, sugar, chemicals, flour, and salt. This smooth paper will stretch about 10 per cent; regular kraft paper will stretch about  $1\frac{1}{2}$  to 2 per cent.

The embossed straight rolling hoops on 55-gal steel drums require special

loading to prevent overriding of the hoops in transit, which loosens the load and dents the drums. The hoops on a new drum, now in use, are embossed in an offset pattern so that the spacing is wider on one side of the drum. Adjacent drums can be keyed together for tighter loading without supplemental dunnage.

### ASHAE, ASRE Merge. Result: ASHRAE

A NEW engineering society, the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), is now in being. It was formed in the merger of two societies: the American Society of Heating and Air-Conditioning Engineers and the American Society of Refrigerating Engineers. In a ballot taken last December, 93 per cent of ASHAE returns and 73 per cent of ASRE returns favored the merger. After the vote, which followed lengthy discussions at separate meetings of the two societies, ASHAE President E. R. Queer and ASRE President Cecil Boling jointly announced that the necessary two-thirds vote had been obtained. President of the new society is Cecil Boling. Membership of ASHRAE is more than 18,000.

When the engineering societies move to the new United Engineering Center, the headquarters of ASHAE and ASRE will be combined.

### ICA Sponsors Chilean Visitor

Arturo Arias, ASTM membership representative for the Laboratory for Testing Materials of the University of Chile, was a visitor at ASTM Headquarters February 10. Professor Arias is director of the laboratory, which in addition to its university work is the official testing laboratory for the Chilean Ministry of Public Works.

Professor Arias is visiting the United States on a three-month technical assistance program sponsored by the International Cooperation Administration. Among the objectives of his visit are the observation of general material testing procedures, including soil mechanics, concrete, and metallurgy, with special attention being given to organization, equipment, investigations and research methods, and relations with industry. His itinerary includes two weeks at the National Bureau of Standards and visits with several technical, professional, and trade associations allied with the building industry.

### Society for Applied Spectroscopy $\frac{1}{2}$ Born

AFTER SOME two years of comprehensive study, the governing board of the Federation of Spectroscopic Societies has dissolved the Federation and founded a national Society for Applied Spectroscopy for individual members. In 18 areas throughout the United States, local sections preserve the autonomy of the founding societies and promote activities that have been distinct to the individual sections. *Applied Spectroscopy*, formerly published by the New York society, is now the official journal of the new national society. Membership is open to all who are interested in spectroscopy and related fields.

Papers are now being invited for a sectional meeting of the society to be held Nov. 4-6 at the Hotel New Yorker. Subjects may include emission and X-ray spectroscopy, mass spectroscopy, infrared and ultraviolet absorption, and gas chromatography. Interested authors should submit title and abstract before Sept. 1 to Dr. M. F. Wilson, Air Reduction Corp., Murray Hill, N. J.

### Japanese Study Team Visits ASTM Headquarters

On February 6, ASTM Headquarters was host to a Japanese building construction team visiting the United States under the auspices of the International Cooperation Administration. The team, comprising seven members, including officers, directors, and managers of Japanese architectural and construction firms, is studying the organization and operations of the housing, building, and construction industry.

Among the team's objectives were a study of organization and management in the construction industry, methods of standardizing the production and use of building supplies, as well as architectural design and mechanization.

Members of the ASTM Staff presented a résumé of Society activities in the field of research and standardization of building construction materials; this was followed by question-and-answer period on matters of special interest to the members of the team.



Japanese Building Construction Study Team which Visited ASTM Headquarters on Feb. 6, 1959.

Standing, left to right: Yasutaro Okura, chief, Estimation Section, Matsui Construction Co., Ltd., Minato-ku, Tokyo; Stanley Smigel, economist, International Housing Service; Shingo Kojima, director in charge, Dept. of Architecture, Nishimatsu Construction Co., Ltd., Minato-ku, Tokyo; David G. Webb, Jr., training program officer, International Housing Service, Housing and Home Finance Agency, Washington, D. C.; Atsushi Fujiki, managing director, Fujiki Komuten Co., Ltd., Osaka; Sadahiko Tamura, interpreter; Maseo Yoshida, director, Sato-Kogyo Co., Ltd., Toyama-City; Weldon J. Brown, training program director, International Housing Service; Harutoshi Fukuzawa, interpreter. Seated, left to right: Yosuke Magara, president, Magara-Gumi Co., Ltd., Kanazawa-City; Dan R. Hamady, assistant to the administrator, International Housing Service; Kakuhei Matsui, team leader and president, Matsui Construction Co., Ltd., Minato-ku, Tokyo; Tadao Miura, director in charge of Technical Research Institute, Taisei Construction Co., Ltd., Tokyo.



# Full Week in Pittsburgh for 33 Technical Committees

## Symposium on Testing of Window Assemblies Simulation, Atomic Energy, and Building Materials Subjects of Talks

**T**HREE OUTSTANDING addresses were heard during the week-long series of ASTM Committee Week meetings at the Penn Sheraton Hotel, Pittsburgh, February 2-6. Committee E-6 on Methods of Testing Building Constructions sponsored a technical Symposium on the Testing of Window Assemblies, at which four papers were presented. Main business of the week, about 300 main committee and sub-committee meetings of 33 ASTM technical committees, was attended by some 1200 people, who were there to discuss and correlate the research upon which new and revised tentatives and standards will be based. Many of these committee activities are summarized in Technical Committee Notes in this issue.

### The Fine Art of Simulation

An address by Dr. John C. Warner, president, Carnegie Institute of Technology and technical consultant to the U. S. delegation at the the Second U. N. International Conference on the Peaceful Uses of Atomic Energy was presented



Dr. John C. Warner, president, Carnegie Institute of Technology, speaker at Committee Week Dinner.

at the Committee Week Dinner on Wednesday, February 4. Speaking on "The Fine Art of Simulation," Dr. Warner defined simulation as "the art of assuming an appearance which is feigned, or not true; an appearance without reality or substance; an ap-

pearance which is meant to deceive... a counterfeit display."

Dr. Warner declared that there is extensive use of the art of simulation in higher education, and visualized the kind of institution that would result from putting together an administrative officer who simulates the role of educational leader, a faculty made up of those who simulate the role of the scholar-teacher, and an enrollment of young men and women who simulate the role of students. "We make a great deal of use of the art of simulation in education at all levels and I believe this is the reason for most of the weaknesses in our educational system," Dr. Warner said.

### The Future and Atomic Energy

On Tuesday, February 3, Dr. William E. Shoupp, technical director, Atomic Power Department, Westinghouse Electric Corp., spoke at the Metals Industry Luncheon sponsored by ASTM committees in the metals field. Speaking on "The Future and Atomic Energy,"



Head Table Guests at Metals Industry Luncheon

Left to right: Robert J. Painter, executive secretary and treasurer, ASTM; K. G. Compton, Bell Telephone Laboratories, Inc., Murray Hill, N. J., chairman, ASTM Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys; T. E. Eagan, The Cooper-Bessemer Corp., Grove City, Pa., chairman, ASTM Committee A-3 on Cast Iron; H. F. Hermann, Mechanical Engineering Dept., Consolidated Edison Co. of New York, Inc., New York City, chairman, ASTM Committee A-5 on Corrosion of Iron and Steel; L. J. Rohl, vice-president and chief metallurgical engineer, United States Steel Corp.; C. H. Sample, The International Nickel Co., Inc., New York City, chairman, ASTM Committee B-8 on Electrodeposited Metallic Coatings; E. J. Holcomb, Specifications Section, Quality Standard Dept., Aluminum Company of America, vice-chairman, ASTM Pittsburgh District Council; Wm. E. Shoupp, the speaker, technical director, Atomic Power Dept., Westinghouse Electric Corp.; Norman L. Mochel, toastmaster, metallurgical manager and consultant, Westinghouse Electric Corp., Phila., past-president of ASTM; Davitt S. Bell, president, Edgewater Steel Co.; F. L. LaQue, vice-president and manager, Development and Research Div., The International Nickel Co., Inc., senior vice-president, ASTM; past-president of the National Association of Corrosion Engineers; I. V. Williams, materials engineer, Bell Telephone Laboratories, Inc., Murray Hill, N. J., chairman, ASTM Committee B-7 on Light Metals and Alloys, Cast and Wrought; G. G. Beard, president, United Engineering & Foundry Co.; J. L. Bonanno, treasurer and chief engineer, The Lionel Corp., Irvington, N. J., chairman, ASTM Committee B-9 on Metal Powders and Metal Powder Products; Prof. W. R. Turkes, associate dean and acting dean, Schools of Engineering and Mines, University of Pittsburgh; Wm. Babington, Bell Telephone Laboratories, Inc., Murray Hill, N. J., chairman, ASTM Committee B-6 on Die-Cast Metals and Alloys; L. C. Marshall, director, Research, Link Belt Co., Research Lab., Indianapolis, Ind., vice-chairman, ASTM Committee A-7 on Malleable Iron Castings.



←  
The speaker at the Metals Industry Luncheon was Dr. William E. Shoupp, technical director, Atomic Power Dept., Westinghouse Electric Corp., Pittsburgh.



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Leland Hazard, vice-president and general counsel, Pittsburgh Plate Glass Co., a master of quiet, dry humor, was toastmaster at the Wednesday evening dinner. Here he tells one of his stories.

Dr. Shoupp discussed our total energy resources in the coming centuries. In speaking of future atomic power plants, Dr. Shoupp stated that there is no one best reactor for all times, places, and sizes, and that the final criterion must be the cost of power output. Present rate of power consumption in the United States is about 800 billion kw-hr per year. A rate of 2125 billion kw-hr per year is predicted by 1975. Domestic coal reserves are enough for 1000 years at the 1975 rate, 180 years at the rate predicted for the year 2000, and only 7 days at the rate predicted for the year 3000, if one assumes the present rate of doubling of power demands each decade is to continue. Dr. Shoupp cited these figures to point out the absurdity of long-time extrapolations.

In comparison, Dr. Shoupp said, our reserves of uranium-235 are enough

for about 50 years at the predicted rate for 1975. Use must be made, therefore, of thorium and uranium-238.

Dr. Shoupp's recommendations for long-term action are: (1) learn to make high converters for using uranium-238 and thorium, (2) develop thermonuclear energy for use in the 21st century, and (3) use thorium and uranium-238 while we still have uranium-235 and plutonium.

#### Common Sense and Building Materials

Robert F. Legget, director, Division of Building Research, National Research Council of Canada, spoke on "Common Sense and Building Materials" at the Building Materials Industry Luncheon, Wednesday, February 4. Mr. Legget's talk appears in this issue.

#### Testing of Window Assemblies

To spark the inauguration of a standardization program for testing of window assemblies, Committee E-6 on Methods of Testing Building Constructions sponsored a Symposium on the Testing of Window Assemblies on Wednesday, February 4. The symposium was developed by Subcommittee VIII on Windows under the chairmanship of R. B. Crepps of Purdue University.

L. M. Dunn, Aluminum Company of America, in his paper, "Need for Research and Development of Test Methods for Windows," cited the long-time outdoor exposure tests conducted by ASTM on aluminum used in window assemblies and referred to the several factors requiring performance standards, ranging from the anchorage of the case in the building to glazing and finishes.



Guests at the Head Table, Building Materials Industry Luncheon

Left to right: Robert J. Painter, executive secretary and treasurer, ASTM; R. H. Faber, The Gypsum Assn., Chicago, secretary, ASTM Committee C-11 on Gypsum; Paul M. Woodworth, director, Research and Development, The Waylitz Co., Chicago, first vice-chairman, ASTM Committee C-15 on Manufactured Masonry Units; Charles S. Ingham, president, Pittsburgh Chapter, American Institute of Architects; A. H. Baker, director, Research, Pittsburgh Corning Corp., Port Allegheny, Pa.; Richard T. Kropf, vice-president and director, Research, Belding Heminway Co., New York City, past-president, ASTM; Robert F. Legget, the speaker, director, Building Research, National Research Council of Canada, Ottawa, chairman of ASTM Committee E-6 on Methods of Testing Building Constructions; Kenneth B. Woods, head, School of Civil Engineering, Purdue University, Lafayette, Ind., director, Joint Highway Research Project, current president, ASTM, past-chairman, Highway Research Board; J. P. Romualdi, assistant professor, Civil Engineering, Carnegie Institute of Technology, chairman, ASTM Pittsburgh District Council; Paul Schweikher, head, Department of Architecture, Carnegie Institute of Technology; A. A. Bates, vice-president, Research and Development, Portland Cement Assn., Chicago, junior vice-president, ASTM; W. J. Krefeld, professor, Civil Engineering and director, Engineering Materials Laboratory, Civil Engineering Research Laboratories, Columbia University, New York City, chairman, ASTM Committee E-5 on Fire Tests of Materials and Construction; T. E. Stelson, acting head, Civil Engineering Dept., Carnegie Institute of Technology; R. E. Copeland, director, Engineering, National Concrete Masonry Assn., Chicago, chairman ASTM Committee C-12 on Mortars for Unit Masonry; M. R. Beasley, vice-president, Research and Development, Central Commercial Co., Chicago, vice-chairman, ASTM Committee D-8 on Bituminous Materials for Roofing, Waterproofing, and Related Building or Industrial Uses.



← The Honorable Thomas J. Gallagher, Mayor of the City of Pittsburgh, touched on the important contributions ASTM has made to industry in general and to Pittsburgh industry in particular, as he welcomed the Society members and committee members.



→ E. R. Weidlein, chairman, Science Committee, Pittsburgh Bicentennial (former president of Mellon Institute) spoke briefly about Pittsburgh's Bicentennial celebration. Committee Week was one of many technical meetings to be held in Pittsburgh during its 200th Anniversary year.

In the paper, "Considerations in Evaluating Factory-Sealed Double-Glazed Window Units," by A. Grant Wilson, K. R. Solvason, and E. S. Nowak, National Research Council of Canada, some experiences in the testing of sealed double windows in Canada were related. The critical factor in both manufacture and test of this type of window has been the type and construction of seal used. Research and test methods should include as important factors: (1) the condition of the unit at each season of the year, and (2) the tightness of units against transmission of vapor and liquid.

The experiences and problems encountered in a large-scale test program conducted in the Pittsburgh area were reviewed in the paper. "Practical Test Experience with Certain Aspects of Glass Performance," by C. R. Frownfelter, Pittsburgh Plate Glass Co. A description of an outdoor testing installation was included in the paper.

"Norwegian Test Methods for Wind and Rain Penetration Through Windows," by S. D. Svendsen and Robert Wigen, Norwegian Building Research Inst., was read by R. F. Leggett, National Research Council of Canada, in the absence of the authors. In the tests described, wind-driven rain with a wide range of velocities was simulated in order to approximate the extremely severe conditions in Norway.



**Distinguished Honorary Member Attends Committee Week**

Mr. Frank N. Speller (right), longtime member of Committees A-1 on Steel and A-5 on Corrosion of Iron and Steel, now retired (age 84), attended the Committee Week dinner in Pittsburgh. He is shown here with J. J. Kanter, Crane Co., chairman of Committee A-1.

### Responsibilities of Science in a Democracy

"IN SPITE of frequent arguments to the contrary, this is the age of science and technology. Under the circumstances it does not seem safe to trust the administration of a modern democratic state to men who are ignorant of the methods of science and of the benefits to mankind which have been made possible through the applications of science. When we have leaders who are not competent in this regard, we as members of the various professions have a special obligation to be alert and to express our views on public problems, especially on those which have elements related to our field of professional competence. Complacency on our part could be fatal to the continued existence of a strong free society."

Excerpt from

*"A message from the President: a Special Responsibility"*

by J. C. Warner  
president, Carnegie Institute  
of Technology and speaker at  
ASTM Committee  
Week Dinner.



Dinner meeting of Committee C-3 on Chemical Resistant Mortars, held at Penn-Sheraton Hotel during Committee Week



# Common Sense and Building Materials

By Robert F. Legget

*The tremendous size of the building materials industry, the place occupied by ASTM standards in building codes, the search for new and better building materials, the status of modular design of building components—all are surveyed here by Robert F. Legget, director, Division of Building Research, National Research Council of Canada, and active ASTM member, in a Committee Week address presented in Pittsburgh.*

**B**UILDING MATERIALS are big business in any country and certainly so in the United States and Canada. A good working rule is to allow between 45 and 50 per cent of the total cost of a construction job for the purchase of materials and equipment. On a 2-million-dollar construction contract, therefore, roughly 1 million dollars would be spent for materials and equipment, mainly materials. Even such a figure as this fails to indicate the real national importance of building materials in general. Taking construction as a whole, the estimated value of construction carried out in the United States during the year 1957 was \$47,300,000,000. It is estimated that of this vast amount at least 20 billion dollars represented direct expenditure on building materials and equipment.

The corresponding figures for Canada are a total value of construction for 1957 of \$7,480,000,000 with a corresponding expenditure on building materials of \$3,383,000,000, or 48 per cent of the total.

One of the objectives of ASTM is to serve this immense field with its necessary standard specifications and standard test methods. All who know the Society will know how well this task has been done down the years. One has only to look at the titles on the collection of volumes of ASTM standards to realize that a very large part of the effort put into the work of ASTM is directly applicable to the improvement of building materials. If one goes further, and looks at the names of specific ASTM committees, one soon finds oneself looking at a roster of all principal materials



The speaker at the Building Materials Industry Luncheon was Robert F. Legget, director, Division of Building Research, National Research Council of Canada, Ottawa.

used in this business of construction. All this is obvious to those who know the Society, but I sometimes wonder if we do not take it far too much for granted.

Lest this sound like a rather jaundiced personal observation, may I illustrate what I have in mind by mentioning a recent publication of the Society. This was first issued in April, 1955, and is a really splendid compilation of all the

## Guests at the Head Table of the Committee Week Dinner

Left to right are: Robert J. Painter, executive secretary and treasurer, ASTM; E. J. Holcomb, Specifications Section, Quality Standard Dept., Aluminum Company of America, vice-chairman, ASTM Pittsburgh District Council; John A. Anthes, assistant director, Research and Development, Dravo Corp.; C. T. Evans, vice-president, Technology and Development, Universal Cylco Steel Corp., Bridgeville, Pa.; G. A. Webb, director, Administration, Mellon Institute; R. A. Lincoln, vice-president in charge of Research, Allegheny Ludlum Steel Co., Brackenridge, Pa.; W. L. Fink, scientific coordinator, Alcoa Research Laboratories, Aluminum Company of America, national director, ASTM; Paul W. Backman, vice-president and manager of Research Dept., The Koppers Co.; R. C. Emmett, president, Pittsburgh Testing Laboratory;

A. Allan Bates, vice-president, Research and Development, Portland Cement Assn. Chicago, junior vice-president, ASTM; M. S. Smith, vice-president and regional manager, Pennsylvania Railroad Co.; C. H. Fellows, retired director, Engineering Laboratory and Research Dept., The Detroit Edison Co., Detroit, past-president, ASTM; E. R. Weidlein, chairman, Science Committee, Pittsburgh Bicentennial; former president of Mellon Institute; F. L. La Que, vice-president and manager, Development and Research Div., The International Nickel Co., Inc., senior vice-president, ASTM; J. C. Warner, the speaker, president, Carnegie Institute of Technology; Leland Hazard, vice-president, Pittsburgh Plate Glass Co., toastmaster; Kenneth B. Woods, head, School of Civil Engineering, Purdue University, Lafayette, Ind., director, Joint Highway





ASTM standards which appear in building codes. It was originally a volume of over 900 pages but it has just appeared in a new second edition now with 1080 pages, and yet sold to members for the small sum of \$6.40. Why do I mention this publication? Because not more than 3000 copies of the 1955 edition were sold. Even this figure does not give a true indication of the situation since more than 20 per cent of the sales were in Canada. When one remembers that every city and every town in this continent has a building code of some sort and that in practically every one of these there are references to ASTM standards, it becomes apparent that there is something missing in general appreciation of what this Society has done and is doing in the field of building materials.

It seems to me, however, that there are signs of a change. Possibly the fact that a national luncheon of the Society is being devoted to some consideration of the service of ASTM to the building industry is, in itself, an indication of this change. There are, however, more straws in the wind. For example, there is the recent publication of a completely new set of Minimum Property Standards by the Federal Housing Administration, in which there are frequent references to ASTM standards. Many will have heard of recent meetings in New York City at which consideration was given to the preparation of a new national housing code. Although this effort was abortive, it did serve to indicate the wide public interest in building codes and to redirect attention to the quiet but steady work of the several agencies which do publish widely accepted building codes, codes which are in quite wide use by cities throughout the United States. In Canada, we have been more

than surprised by the success which has attended the work done on the National Building Code of Canada, an advisory document published by our National Research Council but now in legal use, by local adoption, as a building regulation for municipalities in which live more than one third of the population of our country. In a short time, more than one half of the population of Canada will be living in municipal areas in which the National Building Code is the legal building regulation. And the ASTM special compilation contains almost all the ASTM standards referred to in this Canadian Code.

If there are some who wonder why I approach my main topic by reference to building codes, let me remind them that building codes are not the stupid obsolete obstacles to building progress that is sometimes suggested by popular writers. They are an essential part of the democratic process, when properly prepared and administered, as safeguards for the public in relation to the design and construction of buildings with special reference to the three fundamentals of all good codes—structural sufficiency, public health, and fire prevention. One has only to give a moment's thought to the recent tragic fire in Chicago to realize the vital part that building codes must play in the life of your country and of mine.

Building codes, however, are dull reading, just as technical considerations of most building materials lack the glamor that is attached to more recent developments in other branches of technology. All of us are familiar with the wisecracks made by amateur observers of the building scene to the effect that we still build houses of bricks and mortar just like the Romans. These same people choose to forget that

fortunately we still take hot baths—just like the Romans! There are others who make similarly snide remarks about wood as an outmoded material. The ignorance of such speakers is betrayed by their own words since wood still remains one of the most wonderful of all building materials, stronger pound-for-pound than steel, an excellent insulator in contrast with other structural materials, and one that can be readily and easily worked. Similar comments can be made on other "conventional" building materials. I am often puzzled by the prevalence of the view that just because a thing is old it is necessarily bad and that just because something is new it must be good.

New building materials will come into use, however, as all of us know, but this will not happen overnight and will only come to pass as a result of much hard work, experimentation, and trial use—work so well typified by the regular procedures of ASTM technical committees. Plastics, for example, are an interesting new entry into the building field; without doubt they have a real part to play in the development of new forms of building. The extensive work already being done by Committee D-20 on Plastics is evidence in itself of the remarkable progress already being made in this field. There is, however, the inevitable danger that the public may want to act faster than the facts warrant in using such new materials. We hear, for example, a great deal about silicones; many of us know what really wonderful materials they are. It does not yet appear, however, that they provide the complete answer to the problem of leaky masonry, as some would suggest; in some cases their use on masonry can do more harm than good. Up in my country, a white plastic has been

#### Guests at the Head Table of the Committee Week Dinner (Continued)

Research Project, president, ASTM; The Honorable Thomas J. Gallagher, mayor, City of Pittsburgh; Richard T. Kropf, vice-president and director, Research, Belding Heminway Co., Inc., New York, past-president, ASTM; R. O. Keefer, vice-president in charge of Purchasing and Standardization, Aluminum Company of America; Aiken W. Fisher, president, Fisher Scientific Co.; Jerry MacAfee, vice-president in charge of engineering for Manufacturing Dept., Gulf Oil Corp.; R. E. Peterson, manager, Mechanics Dept., Westinghouse Electric Corp., national director, ASTM; J. B. Austin, administrative vice-president, Research and Technology, United States Steel Corp.; C. A. Brashares, vice-president in charge of Sales, Harbison-Walker Refractories Co.; N. L. Mochel, metallurgical manager and consultant; Westing-

house Electric Corp., Phila., past-president, ASTM; Robert M. Moore, vice-president, Sales, Pittsburgh Coke and Chemical Co.; C. E. Macfarlane, chief materials engineer, Westinghouse Air Brake Co., Wilmerding, Pa.; L. C. Beard, Jr., retired, formerly coordinator of Research, Socony Mobil Oil Co., Inc., New York, past-president, ASTM; M. J. Day, vice-president, Technology, Crucible Steel Company of America; J. P. Romualdi, assistant professor of Civil Engineering, Carnegie Institute of Technology, chairman, ASTM Pittsburgh District Council; A. W. Abeling, chief metallurgist, Pittsburgh Screw and Bolt Co.; Raymond E. Hess, associate executive secretary and technical secretary, ASTM.



## Building Materials...

used to build an igloo, and this little structure received publicity all over the continent. The plastic igloo looked like a real igloo, but unfortunately, wonderful though plastics are, they do not have the same remarkable properties as does compacted snow which is Nature's own combined ventilator, automatic humidifier, de-humidifier, insulator, and structural element.

These two simple examples point to what is perhaps the most significant development today in the whole field of building technology. This is the work now going ahead in the field of research into building materials, not just as isolated materials but in use as integral parts of buildings, that is, in association with other materials, and performing in the environment provided by the indoor and outdoor climates of buildings. This concept of building research is not new. There have always been pioneer workers in this, as in every other field of scientific research. Today, however, this concept of integrated building research as a supplement, or rather as a necessary complement to the splendid research carried out on individual materials, generally by manufacturers and producers, has been publicly recognized in most countries of the world by the establishment of a national building research organization.

Here in the United States, for many years splendid work has been carried out by what is now the Division of Building Technology of the National Bureau of Standards. Despite the legal limitations upon its scope and the limited resources available to it, this building research work at the Bureau is favorably known throughout the world. The pioneer of all national building research organizations was the Building Research Station of Great Britain, established in 1921 and, for a quarter of a century, the only such organization in existence. In Canada, we have the Division of Building Research of our National Research Council (working very closely with the two bodies already mentioned), the staff numbering almost 200, most of them working in a Building Research Center at Ottawa.

There is a real story to be told about this new concept of building research which calls for the integration of almost all major scientific disciplines, in a field of applied research of steadily increasing importance. A luncheon talk does not, however, provide either the time or the occasion for such a review of what is necessarily a somewhat long story and one that necessarily involves consideration of some basic scientific principles. But let me discuss with you one phase

of modern building research, one which has special relevance to the work of ASTM. This might be described as the application of common sense to the dimensioning of building materials and products.

Mention of such a subject may surprise some, since there is little general recognition of any problem at all with regard to the dimensions of common building materials or of building components such as doors and windows. There is such a problem, however, as is soon found in the business of assembling the many thousands of components that must be fitted together in order to make a single house. It will then be found that there is normally little coordination between the dimensions of the different materials and components that are used, apart only from the fact that they can all be measured in feet and inches and fractions of an inch.

If I may make a personal approach in discussing this important matter, it was in the early phases of the housing research work of the Division of Building Research in Canada that we encountered this problem of the dimensions of building materials and components. It required only a little study to show that the problem has been recognized many years before, and dealt with in a most constructive way, in the housing studies of an American engineer, Alfred Farwell Bemis. It was found that he had published in 1936 the third volume of his famous trilogy "The Evolving House" dealing with "Rational Design." In this book he propounded the simple but basic concept of the modular coordination of building materials. He suggested the use of a module of 4 in. as the unit upon which should be based all other dimensions used in building. His concept was taken up and developed as the famous A-62 project of the American Standards Assn. which published the first standard for modular sizes of masonry materials in 1941.

These facts were brought to the attention of a group of interested builders and manufacturers in Canada in 1950. There was general agreement that the idea was sound but we found, as so many others had found, that although everybody agreed that the idea was a good one there seemed no possibility of anybody taking the first step to implement it. The architects said they would gladly design for modular units if they were available. The builders said they would be delighted to use modular units if they could purchase them. The manufacturers said they would gladly make modular units if the architects requested them. There seemed to be no easy way of breaking

into this closed circle of objections.

It was clear that a crucial matter was the size of ordinary bricks. When a study was made of the reason for common brick sizes, it was noted that American bricks first followed the size adopted in earlier years for British bricks—3 by 4 by 9 in. It was found that this size had developed directly from the size of a man's hand, making the holding of such bricks convenient. Today's standard American brick sizes are about one-third smaller than this earlier size. Any conclusion that this change suggests with regard to the size of American hands is not for me to state but must be left to the imagination. Imagination is certainly needed to explain why brick sizes in Ontario are almost exactly intermediate between British sizes and American sizes.

If it be thought that this strange situation regarding the sizes of such a vital building material is peculiar to bricks, let it be added that the same sort of utterly chaotic dimensioning can be demonstrated for most other building materials. As just one example, the standard size of American ceramic tiles is  $4\frac{1}{4}$  by  $4\frac{1}{4}$  in. It is said that this size was developed simply because it will fit diagonally into a 6-in. square. The effect of such irrational dimensioning is demonstrated by the large number of sizes which manufacturers of building products are forced to maintain in order to meet even ordinary demands. I have heard it stated that one American manufacturer of windows has actually listed 30,000 different sizes, a number which suggests that almost every window he made was a "special." Exaggerated though this figure may be, it does suggest that a problem does exist.

With such care and attention being devoted to the manufacture, testing, and improvement of building materials and products, is it not strange indeed that this matter of dimensions has lagged so far behind? Stranger still when it is remembered that a perfectly logical solution was suggested as long ago as 1936. Mr. Bemis' suggested module is the more interesting since 4 in. happens to be almost exactly the equivalent of 10 cm, the difference being approximately  $\frac{1}{16}$  in. I realize that even to mention the metric system to an American audience is possibly indiscreet. When it is remembered, however, that India and Japan have recently adopted the metric system officially, and that even in Great Britain there is now proceeding a top-level and most serious study of the possibility of the British adoption of the metric system, it will be realized that it may soon be indiscreet to neglect this other arrangement of dimensions. A module of either 4 in. or 10 cm, provides

an admirable basic unit. It can be developed into a 40-in. planning grid for architectural design. Its application to product dimensions immediately limits the number of possible variations, while giving all necessary flexibility.

I mention this subject, because, despite inertia as recently as 1950, there is today throughout the world a very real movement toward the wide adoption of modular dimensioning of building products. France issued its first modular standard in 1942. Germany introduced during the war a modular system for building dimensioning, using two modules, for all construction. This work was developed after the war during the reconstruction of West Germany. In 1951 German Standard DIN-4172 was made compulsory for all construction for which public subsidies were being provided. The result was that three quarters of the 400,000 housing units built in West Germany in 1953 were built to modular dimensions, as have been all houses built with public subsidy since that time. Similar official use of modular dimensions in building is now standard practice in the USSR.

In Sweden, perhaps the greatest advance of all has been made since the Swedish Standards Assn. has now published dimensional standards for over 100 building materials and products; these are in regular use by Swedish manufacturers. Norway has taken similar action and has 60 dimensional standards already published with a number more in preparation. In this, as in other research matters, the four Scandinavian countries are working together, so that modular coordination will soon be a regular procedure in the design and manufacture of many building products and materials throughout Scandinavia.

In Great Britain, progress has not been so spectacular, but there was formed some years ago a Modular Society to promote the use of modular dimensions in British building practice. On the Albert Embankment, in the middle of London, there is a rather unusual looking little building with the odd name "Modular Assembly." Inside, it is an exact 20-ft cube; it was designed and built to illustrate the potentialities of modular coordination. A careful survey was made of the opinions of the companies concerned with supplying materials for this interesting research building. Of the 18 who replied fully, 11 claimed specific benefits from even a first trial with modular dimensions, the other 7 being noncommittal or not answering this specific question. All 11 manufacturers stated that lower prices would result from the general use of modular dimensions.

So widespread is this active interest in

building dimensions in Europe that a special project of the European Productivity Agency (under the OEEC) was started in 1953. This has been participated in by 11 European countries with Canada and the United States acting as observers. As this interesting international venture approaches its close, its work will be carried on by a new subcommittee on modular coordination set up under the International Standards Organization, a body the important work of which is steadily increasing year by year.

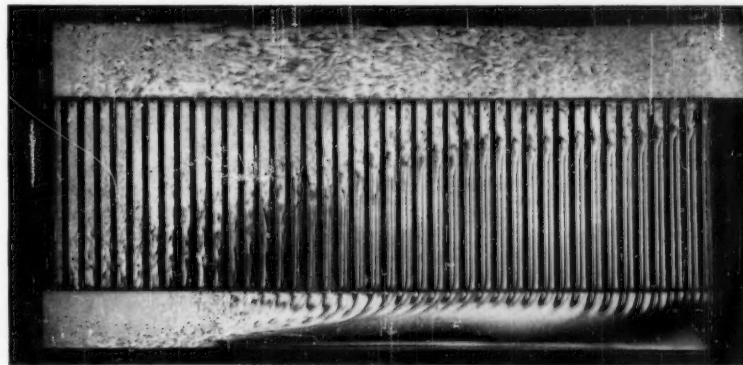
Such in brief is the situation in Europe. Similar interest is being shown in India and in Australasia. What of North America? The work of Bemis in the United States was a truly pioneer effort in this field. It was further developed by the Bemis Foundation. The Producers Council took an active interest in it, as did also the American Institute of Architects, in addition to the American Standards Assn. There has recently been formed the Modular Building Standards Assn. to carry on the good work previously done by all these other agencies but may I be permitted to observe that progress to date has not been spectacular. It is reported that the U. S. Corps of Engineers has been using a 4-in. module in its designs for the last five years. The Veterans Administration is reported to be revamping all its building details to fit to modular dimensions. Modular bricks are now being produced. Concrete block manufacturers, as a group, have gone a long way in the production of their products to modular dimensions. Some other examples could be given.

In Canada, a little more progress has been made and substantial progress is anticipated in the near future. A committee of the Ontario Association of Architects recently studied the matter of

brick sizes. These and similar studies led a prominent Canadian brick manufacturer on our east coast to introduce modular bricks to the Canadian market on January 1, 1958. Other brick manufacturers soon took similar action. With modular bricks now available, further progress seems assured. The N.R.C. Division of Building Research, in association with the National House Builders Assn. and Central Mortgage and Housing Corp., arranged for the construction of a completely modular house in Ottawa. This example is being followed by the erection of much larger buildings designed to modular standards.

The tide, therefore, seems to have turned at long last. It is a tide of common sense which if carried to the flood, can contribute more to economy and real advance in building technology than any other single development now in sight or even in contemplation. There may be some objections that this is regimentation, that the freedom of the individual manufacturer is being taken away. Presumably the same objections, were raised when standard screw threads were first suggested. Let us hope that inevitable progress will not be seriously impeded by any such semantic sorties.

Although the American Society for Testing Materials is not usually concerned with the dimensions of the materials and products for which it prepares such valuable specifications, it has such influence in the building materials field that it can render invaluable assistance in supporting actively this extension of its usual scientific approach to the dimensioning of building materials and products, thus adding still further to the progress of good building, not only in this country but wherever ASTM Standards are used throughout the world.



**Regenerator Model Flow Pattern Depicted by Flowing Birefringence Technique.**

A plastic slice-model of an open hearth regenerator is built and filled with a milling yellow solution. This solution is pumped through the regenerator to simulate gas flow. The pattern is photographed under polarized light and studied to indicate an improved regenerator design. Second Prize, General Black and White or Monochrome Prints, Eleventh ASTM Photographic Exhibit. Jacob Belkin and E. W. Sherwin, U. S. Steel Corp., Monroeville, Pa.



# Technical Committee Notes

Our technical committees are where the actual work of ASTM is done. Meetings of these committees are held in many parts of the United States, and in Canada and in Mexico. During Committee Week in February, many committees meet to put their work into the form of recommendations to be presented at the Annual Meeting in June. A sampling of recent activities of these committees is given in the following pages. Actions on standards are subject to letter ballot in the respective committees and, for the most part, will be reported to the Society in June.

## Metals

### Steel (A-1)

The construction program continues to influence the activity of industrial representatives dealing with ASTM specifications for steel reinforcing bars and for wire and cable for prestressed concrete. A new specification for deformed billet steel bars for concrete reinforcement with 60,000 psi minimum yield point will cover bar sizes Nos. 3 to 11, inclusive, and also the special large sizes, Nos. 14S and 18S.

A special rail steel grade with a 60,000 psi minimum yield point and a minimum elongation in 8 in. of 5 per cent is being added to Specifications A 16. This special grade will be available only as a deformed bar.

Specifications A 431 covering high-strength billet-steel reinforcing bars will be revised to permit use of the divider method, the autographic diagram method, or an extensometer in determining yield point. Also reduced-section tension-test specimens will be permitted. For large-size Nos. 14S and 18S bars, only one tension test for each heat will be required.

In Specification A 421 covering wire for prestressing, a 0.196-in. diameter wire will be added under type BA, which is suitable for cold-end deformation for anchorage. A tensile strength of 240,000 psi minimum and a yield strength of 192,000 psi minimum will be specified. Retests will be provided for when the test specimen breaks outside the gage length. In the inspection clause, provision will be made for certifying the product when inspection by the pur-

chaser is waived. Similarly, in Specification A 416 for seven-wire strand, provision will be made for certification.

### Malleable-Iron Castings (A-7)

Vice-Chairman L. C. Marshall reviewed additional data further supporting the conclusions drawn from his paper "Stress Rupture Properties of Malleable Iron at Elevated Temperatures," soon to be published in the *ASTM Proceedings*. Dr. Marshall appointed a committee to promote the collection and publication of all available data on the high-temperature use of standard and pearlitic malleable castings.

Committee A-7 is investigating the relationship between the current practice for using test specimens to determine tensile properties of malleable iron, and similar practices for other metals.

A progress report was given on atmospheric corrosion test specimens which have been exposed at Kure Beach, N. C.; Newark, N. J.; East Chicago, Ind.; Point Reyes, Calif.; and State College, Pa. In addition to various grades of standard and pearlitic malleable iron, including some which are copper bearing, are two grades of nodular iron and three of steel. The first removal of these specimen castings will be made at Kure Beach, in May, one year's exposure having been completed. Subsequent removals will be made at the end of 3, 7, and 12 years.

### Stainless Steel (A-10)

Specifications A 296 and A 297 covering grades of corrosion-resistant and heat-resistant ferritic and austenitic

stainless-steel castings are being subjected to some extremely important changes. These changes did not appear in Part I of the 1958 *Book of ASTM Standards* but are outlined below for the convenience of producers and purchasers of stainless-steel castings.

*Specifications A 296.*—A new grade is proposed, to be designated CA-40 with the following requirements.

Carbon, per cent.....	0.20 to 0.50
Manganese, max, per cent.....	1.00
Silicon, max, per cent.....	1.50
Phosphorus, max, per cent.....	0.04
Sulfur, max, per cent.....	0.04
Chromium, per cent.....	11.15 to 14.0
Nickel, max, per cent.....	1.0
Molybdenum, max, per cent.....	0.5
Tensile Strength, min, psi.....	90,000
Yield Strength, min, psi.....	65,000
Elongation in 2 in., min, per cent.....	18
Reduction of area, min, per cent.....	30

For grades CB-30 and CC-50 the maximum permissible silicon content is being changed from the present "1.00" to read "1.5" per cent.

*Specifications A 297.*—For grades HH, HI, and HK the minimum permissible elongation in 2 in. is being changed from the present "15" to read "10" per cent. For grade HI, the minimum permissible tensile strength is changed from the present "75,000" to read "70,000" psi and for grade HK from the present "70,000" to read "65,000" psi. These changes are expected to appear in the 1959 versions of Specifications A 296 and A 297.

### New Specifications for Nickel and Nickel Alloy Products

The coverage of nickel and nickel alloys by ASTM specifications will be greatly expanded. A joint group of members of Committees B-2 and A-10 will draft specifications for nickel, nickel-copper, and nickel-chromium-iron castings, as well as for cast welding fittings, valves, and flanges. Much interest in these products has been expressed by people engaged in the nuclear energy program.

In addition, Committee B-2 will be the sole sponsor of specifications for nickel, nickel-copper, and nickel-chromium-iron welded pipe and tube and for



welding fittings, valves, and flanges. The present specifications B 161, B 165, and B 167 will be expanded to cover nickel, monel, and inconel hot-finished pipe and tube. Some adjustments in composition and properties to cover nuclear end uses will be made in specifications B 163, B 167, and B 168 covering inconel wrought products.

Specifications B 160, B 164, and B 166 now cover nickel, monel, and inconel rod and bar. In order to permit the ASME Boiler and Pressure Vessel Committee to establish stresses for forged products, these specifications will be broadened to include forgings.

#### **Electrodeposited Metallic Coatings (B-8)**

Action was taken to double the specified nickel plate thickness in Specification B 142 covering electrodeposited coatings of nickel and chromium on zinc and zinc base alloys. To improve the durability and performance of plated zinc die castings, the new coating, designated Type DZ, would have the following minimum thickness requirements: copper-plus-nickel, 0.002 in.; copper, 0.0002 in.; final nickel, 0.001 in.; and chromium, if required, 0.00001 in.

A proposed specification for electrodeposited coatings of nickel on steel for engineering use is being developed. This specification covers requirements where protection against corrosion, wear, abrasion, erosion, oxidation, or other deterioration of the basis metal is important as well as product protection from iron contamination in vessels used for storage and handling of such materials. The type of nickel coating used will depend upon the requirements of the articles to be coated. Selection must be based on the experience of the manufacturer and the purchaser with regard to the thickness, hardness, ductility, residual stress, and other properties of the nickel coating.

A Symposium on Electroless Nickel Plating sponsored by the committee will be published in 1959. Eight papers and a bibliography will bring together all known information on electroless nickel. Many photographs and tabular data will be included.

#### **Nondestructive Testing (E-7)**

Final agreement has been reached on a radiographic method for quality inspection for internal discontinuities. This method includes requirements for penetrameters which indicate several classes of sensitivity. Publication by ASTM is scheduled for this summer.

Work is progressing rapidly on a joint publication by the Aircraft Industries Assn. and ASTM of a set of reference radiographs for aluminum and mag-

nesium castings. This will be a separate publication from the present Reference Radiographs (E 98) for inspection of aluminum and magnesium castings. In the new document all the negatives will be actual radiographs, whereas in E 98 the radiographic negatives are photographic reproductions.

Reference radiographs for thick-walled steel castings are being prepared using one- and two-million-volt X-ray, gamma-ray, and Betatron radiation. An investigation of radiographic testing of honeycomb structures for aircraft is being conducted. Methods for liquid penetrant inspection are also being prepared.

Committee E-7 will sponsor a two-session Symposium on Nondestructive Testing at the Third Pacific Area National Meeting in San Francisco next October.

### **Engineering Materials for Nuclear Reactors**

The ASTM Special Administrative Committee on Nuclear Problems at its meeting on February 4 during ASTM Committee Week in Pittsburgh reviewed the activities of ASTM technical committees in the area of standards for engineering materials used in nuclear reactors.

Much work is being done in this field by ASTM technical committees, but much more is needed. The Administrative Committee, recognizing that this is probably due to the need for committee people who are familiar with the problems, is planning a series of forums for the Annual Meeting in Atlantic City next June and for the Third Pacific Area National Meeting in San Francisco next October.

One of the most active technical committees has set a pattern for handling reactor materials. During the current developmental stage of reactor technology it plans to add to existing ASTM specifications by addenda the special requirements imposed by the radiation environment. When the number of addenda justify it, separate standards will be prepared.

The Administrative Committee was advised of the need for specifications for sodium, graphite, and heavy water. This need will be referred to the appropriate ASTM technical committees for action.

Dosimetry, the technique of measuring radiation dosage, is being thoroughly evaluated by several groups in ASTM committees. Appropriate standards will soon be published.

Specifications for titanium sheet, plate, tubing, and pipe have been published by the Society. Specifications for titanium rod and bar will probably be published in 1959.

### **Construction Materials**

#### **Chemical-Resistant Mortars (C-3)**

The determination of the chemical resistance of mortars, particularly where mortar is directly exposed to chemicals in various forms, is a critical problem, and therefore a standard method of test to determine the performance has been very much needed. A proposed tentative method has now been approved by Committee C-3. This is a culmination of efforts in this direction covering an eight-year period. Meanwhile, further evaluation of data secured from the use of this method will be studied.

The recommended practices for silicate and sulfur mortars will be revised to clarify and expand the section on chemical resistance. To the recommended practice for resin mortars will be added a section on chemical resistance

Work is under way on specifications for zirconium sponge; ingot flat-rolled products; bar, rod, and wire; tube and pipe; and forgings and extrusions. Specifications for beryllium have been drafted and are under consideration. Task groups have been set up to consider specifications for columbium, lithium, thorium, and uranium.

Special subcommittees have been organized to deal with aluminum and magnesium for reactors, concrete for shielding, ceramics, and petroleum products. Methods for chemical analysis of some of the metals in reactors are being prepared. Nondestructive tests for rating soundness of materials have been developed and published by ASTM, and others are being developed.

Many papers and symposia on nuclear reactor materials have been published by the Society, and others are planned. For instance, at the Third Pacific Area National Meeting there will be symposia on the newer metals, on ceramics, on radiation effects and dosimetry, and on radioisotope test methods. Papers dealing with reactor materials will also be presented during the symposium on spectroscopy, as well as papers on handling and utilization of water and industrial waste water.

It is evident that ASTM is taking an intense and active interest in the materials used in nuclear reactors, as well it should, since they are nothing more than engineering materials exposed to a relatively new environment. For some 50 years ASTM technical committees have been publishing materials specifications generally accepted by industry here and abroad. The new environment simply creates an extension of already familiar work.

## Technical Committee Notes

including a table outlining the various types of resin mortars. The recommended practice for use of hydraulic cement mortars will be completely revised to make it consistent with standards of the Tile Council of America and with the other recommended practices.

The committee has been considering for some time the possible need for expansion of its scope to include membranes and linings used in chemical-resistant masonry. A task force has been appointed to study this matter, including the possible overlap with other ASTM committees.

### Lime (C-7)

What is meant by soundness in lime? At an informal session of Committee C-7, this much-discussed subject was approached from different angles by five speakers. Each discussed soundness as related to a particular use of lime: masonry lime, finishing lime, masonry cements, hydraulic lime, and gypsum. From these presentations, it was apparent that soundness ties in directly with the application, a factor to consider in developing a method of test.

A specification for pozzolans for use with lime has now received a favorable ballot in the committee. The specification covers pozzolans which in the natural state exhibit pozzolanic properties (such as some volcanic ash and lava deposits) and pozzolans produced by calcination of natural siliceous or aluminosiliceous earths. This specification will be a companion to Specification C 379 covering fly ash for use as a pozzolanic material with lime.

### Gypsum (C-11)

A specification for gypsum backing board has been approved, following agreement on further changes in the proposed specification, some of which were editorial. Agreement was also reached on a definition for Type "X" gypsum wallboard.

### Mortars for Unit Masonry (C-12)

The specification for mortar for reinforced brick masonry (C 161) will be withdrawn and replaced by the newer specification for mortar for unit masonry (C 270). A proposed specification for mortar and grout for reinforced masonry will require further consideration owing to a number of negative votes.

A new research program will evaluate the influence of aggregate grading on the properties of masonry mortar. Four laboratories will study mortars of low air content and moderately high air content using a single masonry cement.

One sand will be used by all laboratories with at least one additional local sand being used by each laboratory. Five gradings have been selected to cover a range broader than permitted by ASTM limits. Tests will include void content, specific gravity and absorption, flow as well as flow after suction and water retention of mortar unit weight and air content of mortar, Voss plasticity of mortar, and drying shrinkage of hardened mortar.

### Manufactured Masonry Units (C-15)

The acceptance of a completely revised specification for clay drain tile marks the final phase in the separation of clay and concrete drain tile, both of which were formerly included in Specification C 4, which dates back to 1914. Concrete drain tile is now covered in a separate specification, C 412. The new Specification (C 4) includes three classes of drain tile—standard, extra-quality, and heavy-duty. The new heavy-duty classification covers the use of drain tile in wider trenches dug by drag line.

The study aimed at formulating standard test methods which can be used to evaluate water-retardant materials for masonry units continues to present many difficulties. Several task groups are working to isolate the pertinent factors. Progress is being made on a method for determining transpiration; the relation between this property and absorption is also being studied.

The committee is meeting obstacles in its effort to complete a proposed specification for chemical-resistant power packings. Such a specification must include sections covering a number of properties, sizes, shapes, and materials. Round-robin tests continue; the latest series will establish effective loading rates.

As a result of industry progress and information now being gathered from standardized shrinkage tests, extensive revisions of the several specifications for concrete masonry units are in the offing. The committee expects to consider a third draft of proposed revisions at its next meeting. Meanwhile, the present tentative revisions were approved for adoption as standard.

### Thermal Insulating Materials (C-16)

A new specification and two new methods of test have been accepted: specification for mineral wool hydraulic-setting thermal insulating cement, method of test for breaking strength and calculated modulus of rupture of preformed thermal insulation for pipes, and method of test for density of fibrous loose fill building insulations.

Committee C-16 approved revisions in the following: specification for diatomaceous earth block-type thermal insula-

tion (C 333), specification for diatomaceous earth thermal insulation for pipes (C 334) method of test for mechanical stability of preformed thermal insulation by tumbling (C 421), method of test for mean specific heat of thermal insulation (C 351), and method of test for water vapor transmission of materials used in building construction (C 335).

Other current projects of the committee include the preparation of a specification for roof deck slabs, the measurement of sag tests in insulating formboard, the study of underground thermal insulations, a method for measuring maximum use temperature, round-robin tests on the adhesive strength of coatings, and the selection of a research project on the permeance of various types of insulating materials.

Reflective insulation is one of the newer types of material within the scope of the committee. Its physical properties are now being studied so that suitable test methods may be developed. The properties needed in nuclear applications are also being investigated. Methods for determining the trueness and squareness of pipe covering and block-type insulation are on the program, as are recommended practices for prefabrication or field fabrication of thermal insulation fitting covers and for cutting beveled blocks of preformed thermal insulation.

### Natural Building Stones (C-18)

What is meant by durability and how can it be defined in a specification for natural building stone? This is the major problem before Committee C-18 as it attempts to develop usable specifications for man's oldest building material. No entirely satisfactory criteria have been established for relating measurable properties to the 50- or 100-year service performance of building stone, although specifications have been and are being developed using an escape clause as a substitute. Chairman L. W. Currier, U. S. Geological Survey, stressed this need to the committee at its meeting in Washington, D. C., March 13. Mr. Currier urged that the committee seek to learn whether present specifications are of reasonable value, and he also pointed out the need to tell industry about the work of the committee.

The gap is gradually being closed in the development of specifications for each of the commonly used types of building stone. Specifications are already published for roofing slate and structural granite. The draft of a proposed specification for exterior marble is being circulated in the appropriate subcommittee. The physical requirements upon which this specification is based include absorption, specific grav-

ity, compressive strength, modulus of rupture, and abrasive resistance.

The first drafts of proposed specifications for exterior limestone and for structural sandstone are also under consideration. It was suggested to the Section on Slate that consideration be given to the need for additional specifications in this field for slate for building purposes other than roofing.

#### **Road and Paving Materials (D-4)**

A signal accomplishment was reported at the meeting of Committee D-4—the development of a single consolidated and simplified specification for hot-mixed, hot-laid asphaltic paving mixtures which should be of great aid to the road-building industry. This accomplishment in ASTM was through cooperation with representatives of the American Association of State Highway Officials and the Asphalt Institute.

The committee approved a new tentative method for static immersion type coating test—the result of studies on this subject covering a 20-yr period.

A major contribution from the committee will be the sponsoring of several symposia at the 1959 Annual Meeting in Atlantic City in June and at the Third Pacific Area National Meeting in San Francisco in October. The plans for these sessions indicate that the general theme will be related to the national highway program.

#### **Wood (D-7)**

A method of conducting machining tests of wood and wood-base materials has been approved. This method, based on extensive research, will enable wood users to evaluate the machinability of wood, fiberboard, and wood-particle boards.

A new standard is being developed for evaluating wood preservatives by field tests. Methods of preservative treatment of wood, which will be coordinated with the American Wood Preservers' Assn., are being prepared.

Some changes were made in the standard method of testing glue joints in laminated products intended for exterior service. Recent research has reduced the time required for such a test from 12 to 8 days, and every effort is being made to reduce the time still further.

The committee also received a progress report on the \$250,000 wood pole research and testing program now being completed. A final report will summarize test results, present an analysis of test data, and give conclusions and recommendations. It will be used by the sectional committee on specifications for wood poles functioning under the American Standards Assn.

In a half-day session devoted to the uses of wood, the subjects discussed in-

cluded the role of genetics in forest management and its implications in wood utilization; status of dimensional stabilization of wood; progress on adhesive development; current developments in sandwich construction for buildings; and paints and paint maintenance—all presented by experts in these fields from the Forest Products Laboratory.

#### **Bituminous Materials (D-8)**

Committee D-8, now in its 54th year, approved the formation of a new subcommittee for industrial pitches, to be organized at the June meeting of the committee.

The acceptance of two new tentative methods of test represents an important advance in the difficult field of accelerated weathering tests. One method covers the determination of failure end point in accelerated and outdoor weathering of bituminous materials, and the other covers the preparation of accelerated and outdoor weathering test panels of bituminous coatings.

Standards are being developed for bituminized fiber pipe which also is a new field of activity for the committee.

In the area of built-up roofing standards, four proposed test methods have been developed, relating to: translucency of mineral surfacing for built-up roofs to ultraviolet light, moisture in aggregate for built-up roofs, hardness of mineral surfacing used on built-up roofs, and sieve analysis of mineral surfacing for use on built-up roofs. In addition, a proposed specification for bituminous-saturated woven-glass fabrics for use in waterproofings was approved.

#### **Fire Tests (E-5)**

The "tunnel" test and so-called "small scale" test for determining flame spread were subjects for most intensive discussion at the meeting of Committee E-5. The "tunnel" test (E 84), although recognized by leading code authorities, has been restricted to a very limited number of available test facilities. This situation has now been relieved by additional facilities and more correlative data are becoming available. If approved by committee letter ballot, this method will be recommended to the Society for adoption as standard at the Annual Meeting. The committee approved a revision of the present tentative to conform with the procedure now being used by those conducting this test.

A new method of fire test applicable to window assemblies, now being developed, will include the testing of glass block and other light-transmitting panels when used in exterior wall openings to retard the passage of fire.

Revisions are being considered of the methods of fire tests of building construction and materials (E 119), which is the established method referred to in building codes for testing full size panels. Changes are in the section on time of testing and, in particular, establish the relative humidity and temperature of air in the seasoning room. A new section on application is to be included which will recognize the use of this test procedure for classifying ceilings which are not an integral part of a floor construction.

Task groups are reviewing two of the so-called "small scale" types of fire test: the radiant panel test and the "small tunnel" test. The radiant panel test has been recognized by Committee D-20 on Plastics but has been referred to Committee E-5 as the proper committee to promulgate this method as an ASTM standard. Both of these test methods will be considered either as a type of rating test or as strictly a research or screening type of test, this latter type being needed by a number of other ASTM committees concerned directly with materials.

#### **Methods of Testing Building Constructions (E-6)**

The newest development in Committee E-6 undoubtedly is the inauguration of a work program by the Subcommittee on Windows, whose first effort will be to collect all available methods on the testing of windows for such properties as air infiltration, rain leakage, heat transfer, and strength. Methods of testing vapor barriers beneath concrete slabs-on-ground or in crawl spaces are under development. A second draft of a proposed group of test methods which measure the significant properties of vapor barriers is being prepared. A proposed method of test for bond strength of masonry walls will now be submitted to committee ballot with the addition of certain illustrations which will aid in the interpretation of the method. A task group has been formed to prepare a method of test of the resistance to shear and diagonal tension of masonry walls.

In the development of proposed test methods for light trusses, panels for light building construction, and completed structures, it has been felt that there was a definite overlap of scope. It is now proposed to set up a joint task group of the three subcommittees involved to review the load tests required to cover all desired applications.

A summary of factors to look for in buildings which relate to durability has been suggested. The Subcommittee on Sound Transmission is reviewing the differences between the American Stand-



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ard (Z24.19) and the ASTM standard (E 90). A test program is under way which will study the sound transmission of light walls.

### Chemicals, Chemical Products, Petroleum, and Water

#### Petroleum (D-2)

A joint meeting of Committee D-2 on Petroleum Products and Lubricants and Committee D-16 on Industrial Aromatic Hydrocarbons and Related Materials was featured by a Panel Discussion on Nuclear Technology and a Symposium on Hydraulic Fluids.

The panel discussion was arranged to foster a better understanding of nuclear technology related to fuels and lubricants so that Committee D-2 could better assess the need for committee activity in this area. There were four papers:

"Review of Applications of Nuclear Energy that May Affect Fuel and Lubricant Properties," by C. G. Collins, General Electric Co., Cincinnati, Ohio.

"Review of Current Research and Development Efforts on Fuels and Lubricants for Nuclear Applications," by R. O. Bolt, California Research Corp., Richmond, Calif.

Prepared Discussion by A. A. Schwartz, General Electric Co., Schenectady, N. Y.

"Review of Activities of ASTM Committee E-10 on Radioisotopes and Radiation Effects," by G. W. Pomeroy, General Electric Co., Cincinnati, Ohio.

"Review of Need for Modified and New Test Procedure for Fuels and Lubricants Associated with Nuclear Radiation," by A. S. De Martini, Esso Research and Engineering Co., Linden, N. J.

The consensus was that there is a need for a Subcommittee on Nuclear Matters within Committee D-2 to follow closely developments in the nuclear field that may be of significance to fuel and lubricant requirements. Copies of the panel proceedings are being made available to the interested subcommittees of Committee D-2. Others interested may request copies from W. T. Gunn, Secretary of Committee D-2.

At the Symposium on Industrial Applications of Hydraulic Fluids three papers were presented:

"Suggested Practices for Fluid Change-over in Hydraulic Systems," by A. S. Morrow, Shell Oil Co., New York, N. Y.

"System Performance with Fire-Resistant Fluids," by R. L. Leslie, Vickers, Inc., Detroit, Mich.

"What Do We Mean by Fire Resistance?" by John Panek, General Motors Corp., Detroit, Mich.

The paper by Mr. Morrow reviewed

considerations involved in converting from one fire-resistant fluid to another; or from oil to a fire-resistant fluid. The influence of hydraulic fluids on cavitation, flow properties, compressibility, and other performance factors was discussed in the paper by Mr. Leslie. The third paper presented an interesting color film reviewing the various criteria that a large corporation might use in selecting hydraulic fluids for different applications. The film depicted spray flammability tests of various hydraulic fluids.

The committee has completed plans for a Symposium on Hydraulic Fluids to be held at the Third Pacific Area National Meeting in San Francisco.

#### Coal and Coke (D-5)

An enormous amount of sampling data and records of members' experience with sampling are being assembled to establish a standard method for the mechanical sampling of coal. This method will cover ordinary commercial sampling and also will provide for special cases where increased accuracy is required, such as in classification of coal by grade or rank. As an adjunct to this method, a proposed method for determining variance components of coal is also being developed. Such data are necessary to establish a coal sampling procedure of known accuracy.

A method for preparing the coal samples for laboratory analysis is being studied by the committee for eventual consideration as standard.

Collaborative work to refine the Gieseler-type plastometer method of determining the plastic properties of coal has been completed. This method will be developed for consideration as an ASTM standard.

Two proposed methods of measuring the change in volume and pressure of the coal mass during carbonization for coking were published 15 years ago, and the experience gained with this apparatus will be the basis for revising the methods. These methods are: the measurement of pressures developed during carbonization of coal by the Russell movable wall oven, and the measurement and test for expansion properties of coal for use in by-product coke ovens by means of the Bethlehem test oven.

Committee D-5 has actively supported the work of the International Standards Organization (ISO) Technical Committee 27 on Solid Mineral Fuels and has sent representatives of the American group to meetings in Europe. W. L. Glowacki attended the meetings of Working Group 8 on Physical Tests of Coke held in Paris, January 26. Mr. Glowacki presented the U. S. case for wire sieves as being preferred to square-

hole punched sieves which are used in Europe. As a result of his presentations, wire sieves have been designated as an acceptable alternate for the punched sieves pending approval by ISO/TC 24 on Sieves. Mr. Glowacki also presented the case for the ASTM tumbler test for coke (D 294), which was placed on the agenda for future study.

#### Soap and Other Detergents (D-12)

As a result of a survey of all existing ASTM specifications for soaps and other detergents, action was taken by Committee D-12 to withdraw the specifications for palm oil solid and chip soap and olive oil solid soap, on the basis that these soaps are no longer commercially significant. Studies are being conducted to determine what specifications should be developed for new types of soaps and detergents, including so-called "specialty" soaps and detergents used primarily for building cleaning and maintenance. More work on liquid soaps is planned. Three new methods were recommended for publication as tentative: acid wash color of detergent alkylate, determination of anionic synthetic detergents in soap by cationic titration, and analysis of sodium tripolyphosphate by the reverse-flow ion-exchange method. A method of test for soil redeposition was approved for publication for information only.

#### Industrial Water (D-19)

New text for a second edition of the Manual on Industrial Water has been approved by Committee D-19. After final editing, the committee hopes to submit the new chapters to the Society for publication later this spring. The committee recommends that all actions on D-19 standards and tentatives at the Annual Meeting this June appear in the manual, to be published as soon as practicable after the Annual Meeting.

Arrangements for two symposia were approved. The first, on identification of water-formed deposits, is planned for the Annual Meeting. The second and more extensive symposium, on technical developments in handling and utilization of water and industrial waste water, is planned for the Third Pacific Area National Meeting at San Francisco in October.

The Committee expects to submit to the Society at the Annual Meeting new tentative methods on chromium in industrial waste water, toxicity of industrial waste water to diatoms, zinc in industrial water, copper in high-purity water, crystalline silica in high-purity water, and measurement of radioactivity in industrial water. New definitions of "acidity," "alkalinity," and "basicity"



were approved for submittal to the Society as a revision of terms relating to industrial water and industrial waste water (D 1129).

Important new committee projects include methods for biochemical oxygen demand, for detergents in industrial waste water, and for sampling water for measurement of radioactivity. A comprehensive bibliography on radioactive tracer testing as applied to industrial water is planned.

#### **Carbon Black (D-24)**

In common with other committees dealing with bulk products, Committee D-24 is concerned with sampling and has a subcommittee on this subject. At its meeting in Pittsburgh, the committee heard reports from two task groups investigating sampling methods, one for bag sampling and the other for hopper car sampling. The report on bag sampling was favorable and a draft method for sampling bags will be prepared for submission at the June meeting. The report on hopper car sampling indicated that additional work is needed before a method can be drafted.

Two subcommittees are investigating tests for high-color types of carbon black. Study of a test for volatile matter indicated that for high-color blacks a new test with better precision and reproducibility is needed. On the other hand, available methods seem quite satisfactory for rubber-grade blacks.

The Subcommittee on Optical Tests has been investigating methods for relative tinting strength of carbon black. It was brought out that the paint and ink industry has a special interest in this type of test and has developed, under the auspices of Committee D-1, a method of test for mass color and tinting strength of color pigments (D 387) that is applicable to carbon black. It was indicated that work on tests applicable to the pigment uses for paints and inks would be undertaken only if adequate representation from the paint and ink producers is obtained on the committee.

#### **Halogenated Organic Solvents (D-26)**

Committee D-26 has organized 5 subcommittees and generally outlined a program of work. The work of Subcommittee I on Definitions and Nomenclature will be guided initially by Emanuel Rosenblat of Fine Organics, Inc., New York, who has agreed to serve as temporary chairman. Subcommittee II on Vapor Degreasing will develop standards relating to the vapor degreasing process and its industrial application. Appointment of a chairman of this group has been deferred pending the

solicitation of additional consumer members. R. A. Boerke of the C. B. & Q. Railroad, Aurora, Ill., has accepted the chairmanship of Subcommittee III on Cold Cleaning which will prepare standards pertaining to the physical and chemical requirements and use of solvents in other than the vapor phase. Robert T. K'Burg of E. I. du Pont de Nemours & Co., Electrochemical Department, Wilmington, Del., is chairman of Subcommittee IV on Test Methods which has adopted the following scope: (a) establishment of specifications and test methods for chemical and physical properties of halogenated organic solvents, (b) establishment of test methods and procedures for determining suitability of such solvents and mixtures thereof for their intended applications.

Subcommittee V on Industrial Hygiene will be concerned with toxicity and decomposition of halogenated solvents as related to inhalation of vapors and methods of control. N. E. Whitman of Bethlehem Steel Co., Inc., Bethlehem, Pa., was appointed chairman of this subcommittee.

### **Organic and Fibrous Materials**

#### **Rubber and Rubber-Like Materials (D-11)**

The Pittsburgh meeting of Committee D-11 was highlighted by the presentation of two technical papers: "The Langley as a Unit for Timing Outdoor Exposures," by C. R. Caryl, Desert Sunshine Exposure Tests, and "Mooney Cure Test for Calculating Times," by A. E. Juve, The B. F. Goodrich Co. These papers will be published in future issues of the BULLETIN.

The Subcommittee on Packings recommended revisions of the method of test for compressibility and recovery of gasket materials (D 1147) to bring it into agreement with the specifications for nonmetallic gasket materials for general automotive and aeronautical purposes (D 1170). The changes include a revised table listing the conditioning and test loads for gasket materials. A procedure for maintaining 50 to 55 per cent relative humidity similar to that covered in Method D 1170 will also be added.

A task group has been appointed to develop a method for the determination of the staining of white compounds when in contact with compounds containing carbon black.

Following a recommendation from the SAE-ASTM Committee on Automotive Rubber, action was taken to revise the method of test for change in properties of elastomeric vulcanization resulting from immersion in liquids (D 471) to include a new reference fuel consisting

of a mixture of equal parts by volume of isooctane and toluene.

A new project in which considerable interest has been shown is the study and development of methods of test for tire cord adhesion. Two task groups have been appointed, one to develop methods of test for textile cord adhesion and the other to prepare adhesion methods relative to wire cord and bead wire.

An ultrasonic method for nondestructive testing of bonds between friction materials and metals has been approved for inclusion in the methods of testing adhesives for brake lining and other friction materials (D 1205). Comments on this new method are being solicited from Committee E-7 on Non-destructive Testing.

The Subcommittee on Coated Fabrics appointed a new task group to investigate and recommend a method for determining the flame resistance of coated fabrics. Consideration will be given to several types of fire tests such as the horizontal, vertical, and angle types. Arrangements were made for undertaking a round-robin test program.

A recently completed test program has shown that ASTM fluid aging method D 471 can be used satisfactorily at test temperatures up to 300 F. The work was done by a task group including representatives from the fluid aging subcommittee of the SAE-ASTM Committee on Automotive Rubber, working with Subcommittee XIX of ASTM Committee D-11. Higher temperature requirements in both the automotive and aircraft industries are pushing standard test temperatures above the previous norm of 212 or 250 F. A careful analysis of such variables as elastomeric composition, heating method, contamination, and testing techniques showed the test method to be adequate when evaluated on a round-robin basis among five laboratories, using test temperatures up to 300 F. In view of the trend toward use of these materials at ever higher temperatures, further work on the method is planned at temperatures above 300 F.

#### **Plastics (D-20)**

Polymers, the basic molecular building blocks for numerous natural and synthetic materials, are the subject of a number of analytical methods. It is in the analytical area particularly that common interests exist among the committees dealing with paint, rubber, adhesives, plastics, textiles, etc.

Committee D-20 has developed tests for dilute solution viscosity, for vinyl chloride polymers (D 1243), and for ethylene polymers (D 1601). Committee E-1 will be asked to prepare a general

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test method for solution viscosity of polymeric materials and to bring the various interests in the Society to some agreement as to a general test.

A full day's symposium on ablation testing—that is, testing the ability of plastics to withstand extremely high temperatures as encountered in missile nose-cone reentry conditions—will be held in the fall. This subject will occupy much of the attention of the reinforced plastics subcommittee. Committee D-20 will sponsor two symposia at the Pacific Area Meeting—one on reinforced plastics and the other on trapped free radicals in irradiated polymeric material.

Committee D-20 has recommended 8 new tentatives to the Society: three test methods for rigid cellular materials—compressive and tensile properties, and density; new specifications for extruded acrylic sheet and for allyl molding compounds; tests for tensile heat distortion temperature of plastic sheeting, and for analysis of urethane foam raw materials; and a recommended practice for operating carbon-arc-type exposure apparatus for plastics. Approved for recommendation as Annual Report actions are a test for flammability for plastic foam, a specification for rigid PVC, an oven heat stability test, and a method for particle size determination. Three new items for the Annual Report relate to plastic pipe—specifications for PVC and flexible polyethylene pipe, and recommended thread profiles for reinforced plastic pipe. The well-known environmental stress-cracking test for polyethylene will be considered for publication as tentative.

Subcommittee XIII on Statistical Techniques has drafted recommended practices on sampling, and on experimental design. The committee held the first of a series of indoctrination lectures on statistics to acquaint members with this useful mathematical tool.

### Electrical and Electronic Materials

#### Magnetic Properties (A-6)

A new method of test for a-c magnetic properties of laminated core specimens (A 346) has been issued in the 1958 Book of ASTM Standards. Other test methods have long been available for tests of the intrinsic properties of magnetic materials through the use of standard samples and well-standardized test methods.

Previously, no standard test methods were available for the magnetic lamination industry, and differences in measurements between different production

or laboratory groups were rather large. To give an example, the measurement of exciting current has been found to vary by as much as 25 per cent between different groups on the same laminations. The new standard A 346 provides a method of test and a description of the proper type of instrumentation which should reduce errors in such measurements to below 5 per cent. This should provide both the makers and users of laminations with a better base for the operation of their industry.

The matter of test methods for wound cores, particularly for magnetic amplifier and reactor applications, is being studied by a task group taking as its base the proposed recommended practice for toroidal magnetic tape wound cores published for trial use by AIEE and a proposed standard for presenting data on magnetic amplifier core materials published by AIEE in April 1958. In addition to these two standards, the task group is using the AIEE proposed standards for core test methods for toroidal magnetic amplifier cores which were presented by the materials subcommittee of the AIEE Magnetic Amplifier Committee, as Paper No. 58-71. The group also intends to take into account any work which may have been done on this subject by the Electronic Industries Assn., and while the committee does not presently plan to set standards for the core properties it does plan to standardize the method of magnetic testing. Anyone interested in assisting in this work or contributing to the proposed standard methods of test should get in touch with the committee.

A working group has been formed to look into the proper methods of making tests of materials which have been formed into magnetic shields. Test methods are already in existence for making measurements of the intrinsic properties of these magnetic materials, but there are no standardized test methods for measuring the fabricated parts. The problem is to determine their real effectiveness for shielding under different kinds of conditions. Attention will be given to studies of d-c and a-c test methods to find the most desirable type of test for the various kinds of shielding required. Persons having an interest in magnetic shielding or the method of measuring magnetic shielding should get in touch with the committee so that the point of view of all interested parties can be understood and considered in preparation of the standards.

#### Metallic Materials for Electrical Heating, Electrical Resistance, and Electrical Contacts (B-4)

According to a new tentative method submitted to the Society by Committee

B-4 one can now determine the surety of make of electrical contacts. With the new method one can determine the voltage necessary to produce circuit continuity through electrical contacts under a specified pressure and measure the resulting contact resistance with a specified current. These measured characteristics are extremely dependent upon surface films which change with time, ambient atmospheres, and other variables. However, where stable films exist on the contacts, such as with sulfided silver, the new method has been found to give uniform results in different laboratories. The method should be useful for comparing contact materials and for determining the effect of specific ambient conditions on contact resistance and necessary circuit voltage.

Among other activities in the contacts subcommittee, the physical properties section is attempting to correlate various physical properties of contact materials with their electrical characteristics so that the number of physical properties needed for evaluation purposes might be reduced to a minimum. Properties known to be important include hardness and thermal conductivity. There is no ASTM test for thermal conductivity that is applicable to metals and semiconductors, although there are thermal conductivity tests for thermal insulation. This is a property of metals and semiconductors of considerable interest for applications such as thermocouples and thermoelectric materials.

The section on static connectors and connections is developing a program to evaluate atmospheric-corrosion conditions on static contacts. The group plans to set up some static contact devices under shelter at various exposure test sites. The corrosive effect will be evaluated by periodic measurements of contact resistance, and tests will be carried out simultaneously under laboratory conditions for comparison.

The section on sliding contacts is investigating laboratory devices providing a moving contact. The committee is not currently concerned with brush type contacts such as are used on commutators but rather the type used in switches, etc. Devices under investigation include a phonograph disk, a rotating cylinder, and a laboratory abrasion instrument using a rotating disk.

The subcommittee on resistance materials will have several actions to be included in this year's Annual Report. These will include a new specification covering drawn or rolled nickel-chromium and nickel-chromium-iron alloys for electrical heating elements and a method for accelerated life test of iron-chromium-aluminum alloys for electrical heating. With the approval of

these items, the committee will recommend withdrawal of Specifications B 82 and B 83, which will become obsolete. The committee will also submit concurrently a revision of the accelerated life test for heating materials (B 76).

#### **Electrical Insulating Materials (D-9)**

Committee D-9 has established two new subcommittees in recognition of a growing problem in the electrical industry related to composite materials and to thermal capability. The Subcommittee on Composite Materials will develop standards for various combination materials such as are used in slot liners for motors and for other applications. Formerly thermal capability was coordinated in Section K under Subcommittee XII on Electrical Tests. It was felt that the problems relating to thermal capability could be handled best in a separate subcommittee. This subcommittee can also serve as a focal point of coordination with AIEE on matters relating to thermal classification of insulating materials.

Committee D-9 will sponsor a technical session at the Second National Conference on Application of Electrical Insulation, sponsored jointly by AIEE and NEMA. Theme of the conference will cover high temperatures, new materials, and test methods as applied to the fields of rotating machinery, transformers, and switch gear and electronics. ASTM will sponsor the session on test methods, concentrating on problems of measuring dielectric strength.

The first group of proposed tentatives completed by Subcommittee II on Radiation Effects, jointly with Committee D-20 on Plastics, covers a recommendation for use of the unit "rad" as a measure of radiation dose, a recommended practice for exposure of polymeric materials to high-energy and nuclear radiation, and a recommended practice for measuring radiation dose in which radiation dose is measured by oxidation of a ferrous salt, which is useful for intensities up to 40,000 rad.

A proposed tentative method for sampling and testing untreated mica paper and a proposed tentative method for dielectric constant and dissipation factor for expanded cellular plastics have been approved for ballot.

A feature of the D-9 meeting was a Symposium on Electrostatic Phenomena with the following papers presented:

"The Theory and Measurement of Static Electricity in Polymers," V. E. Shashoua, E. I. du Pont de Nemours & Co., Inc.

"Rotating Probe Electrometer," S. I. Reynolds and A. C. Devine, General Electric Co.

"Evaluating Antistatic Finishes," Fred H. Steiger, Rohm & Haas Co.

#### **Materials for Electron Tubes and Semiconductor Devices (F-1)**

The Symposium on Cleaning of Electronic Components and Devices, held in the fall of 1958 under the sponsorship of Committee F-1, brought into sharp focus the need for evaluating cleanliness of parts as well as the degree of cleanliness of ambient atmospheres and cleaning materials. Committee F-1 has acted to fill this need by establishing a new Subcommittee X on Contaminants. The subcommittee will formulate standard methods for evaluating atmospheres and various cleaning solutions and materials. It will also develop standard methods for determining how clean a particular component or material is. While this activity is of particular interest to the electron tube and semiconductor industry there is also interest in the precision-instrument and mechanical industries as well as in the atomic energy industry.

Interface impedance measurements have occupied the committee over a number of years. This interface condition develops in a tube cathode between the coating and the cathode sleeve and affects the usefulness of a tube in many applications. The method currently used, which represents the culmination of much work by the committee, is designated F 300-57 T. Improvement of this method is a continuing job for the committee. Because of the rather considerable long-term interest in this subject, a history of interface-impedance activities in the committee is being prepared. The committee plans to submit this report for publication in an electronics journal in the near future.

Other projects in the cathode group are concerned with development of a reference planar diode, measurement of cathode temperature, and evaluating methods to determine adherence of cathode coatings. The subcommittee on insulators is currently developing mica standards, in particular, tests for measuring the size of holes in mica splittings. The precision of this measurement is important since the size of the hole affects the mechanical stability of the tube assembly. Present methods involve the use of a tapered pin which is inserted in the hole either by hand or by electrical or hydraulic means. There is evidence that the non-manual method of inserting the pin may be an improvement.

The subcommittee on strip is developing a specification for strip with a high thermal conductivity and is also investigating methods for measuring emissivity. The subcommittee on wire is developing methods for measuring out-of-roundness and is studying meth-

ods other than weighing for measurement of the wire diameter. A common method for measuring diameter of fine wire is to weigh the wire and to use the density-weight-length relationship to calculate the diameter, assuming the wire to be uniformly round. The subcommittee on metallic-nonmetallic seals is continuing the development of evaluating thickness of oxide coating on sealing alloys by a color comparison method. This is proving to be difficult although there is promise that such a method may provide information which will correlate with the ability of the alloy to seal to glass. This group is also evaluating methods for measuring expansivity up to 1000 C. Other tests under consideration are thermal conductivity; modulus of rupture at room temperature, 500, and 1000 C; and dielectric tests. These are of interest on the glass and ceramic materials used for sealing purposes.

#### **Testing and Analysis**

##### **Methods of Testing (E-1)**

A report on studies of rheological testing of elastomers at low temperatures has been presented to Subcommittee 27 on Low-Temperature Testing of Elastomers and Plastics of Committee E-1. This report described additional cooperative laboratory studies of the shear recovery method. Previous work had indicated that this method might be a means of describing the rheological response of elastomers at low temperatures.

The committee will prepare a report which will correlate the several low-temperature test methods for elastomers which have previously appeared in ASTM publications.

A new proposed tentative method for determination of shear modulus at room temperature will be submitted to committee letter ballot. This method covers apparatus, specimens, and procedures for the determination of shear modulus of structural materials at room temperature from twisting tests of bars or tubes of circular section.

Revisions were made in the method for determination of Young's modulus at room temperature (E 111). A companion method for determining Young's modulus at elevated temperatures by dynamic methods will be considered.

The extensive studies made in eight cooperating laboratories of the relationship between Rockwell C hardness and tensile strength of metals have been completed. Based on the extensive data obtained, the committee has prepared several curves which will be recommended for publication along with appropriate tables showing this relationship.



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A new proposed tentative method of test for bulk density of abrasive grain will be submitted to committee letter ballot. This method has been developed at the request of and with the cooperation of the Abrasive Grain Assn.

By means of a Symposium on Shear Testing planned for 1960 it is hoped to define the variables in this type of test, also the difficulties, advantages, and disadvantages for a variety of shear test techniques as applied to a wide variety of materials.

Problems dealing with speed control equipment in determining the speed of testing are under consideration, including the ability of testing machines and

extensometers to meet the very severe requirements for tests at very high strain rates for materials being used today in missiles and rockets. The ASTM recommended practice for short-time elevated-temperature tension tests of materials (E 21) now specifies strain rates up to 0.1 in. per in. per min. Presently available testing machines and strain recorders may not function accurately at these speeds. Action was accordingly taken to organize a task group to consider this problem.

### Emission Spectroscopy (E-2)

Several suggested methods for emission spectroscopy were approved by Committee E-2 for publication as information only. A comprehensive sym-

posium on excitation sources will be presented at the Annual Meeting in June, to complement the 1946 symposium on spectroscopic light sources.

### Absorption Spectroscopy (E-13)

Committee E-13 has approved for publication, as information only, proposed general techniques for infrared and ultraviolet spectroscopy, as well as a proposed editorial format for absorption spectroscopy methods. The new subcommittee on nuclear magnetic resonance spectroscopy is evaluating current methods for presentation of data, with the hope of achieving greater uniformity of presentation. Standardization of nomenclature is being undertaken.

## Two New Committees Swing into Action

### Electrical Insulating Liquids and Gases (D-27)

The organization meeting for the new Committee D-27 was held in Washington, February 16-18, in conjunction with meetings of Committee D-9 on Electrical Insulating Materials. Nucleus for the new committee was the former Subcommittee IV on Liquid Insulation of Committee D-9.

The new committee elected the following officers: chairman, Frank M. Clark of General Electric Co.; vice chairman, Earl R. Thomas, Consolidated Edison Co.; recording secretary, C. A. Johnson, Socony Mobil Oil Co.; and membership secretary, Raymond M. Frey, Line Material Industries.

The committee will operate under the following scope:

**Scope:** The promotion of knowledge pertaining to electrical insulating liquids and gases, whether of synthetic or natural origin, and the recommendation of standards pertinent to these materials.

Standards peculiar to solid insulating materials and varnishes, and the development of standards pertaining to non-electrical uses of liquid and gaseous materials are excluded from the scope of Committee D-27. Developments in these fields incidental to the normal work of Committee D-27 will be coordinated with the appropriate technical committees of the Society.

The committee has approved a tentative plan for organizing subcommittees covering two groups, one on materials (mineral oils, synthetic liquids, and gases), and the other on methods (electrical tests, chemical tests, and physical tests). This type of organization is similar to that of ASTM Committee D-2 on Petroleum Products and Lubricants with which this committee has

much in common. The committee will continue a liaison with Committees D-2 and D-9 and will plan some of its meetings in conjunction with Committee D-9 meetings.

Committee officers will welcome inquiries from companies and individuals who may be interested in participating in its activities. The committee is especially anxious to expand its representation among companies interested in dielectric gases.

### Industrial Chemicals (E-15)

On Thursday, February 19, at the Society's Headquarters, ASTM launched a full-scale, across-the-board activity in industrial chemicals with the organization of Committee E-15 on Analysis and Testing of Industrial Chemicals. The scope for organization of the new committee:

(a) To develop or formulate standard methods for the analysis and testing of industrial chemicals. (Industrial chemicals as used in this scope are defined as single elements or compounds in various stages of purity for consumption primarily by the chemical industry for further conversion.)

(b) In cooperation with other committees of the Society and other organizations, to coordinate and reconcile chemical analytical methods for nonmetallic materials and chemicals that are broadly applicable.

(c) To encourage the use of uniform methods of analysis.

(d) To formulate standards for nomenclature, definitions, and methods of sampling pertaining to analysis and testing of industrial chemicals.

(e) To establish precision and accuracy of standard analytical and test methods for chemicals, and

(f) To encourage the establishment of

new product committees in the field of industrial chemicals when needs become evident.

Note: Specifications are specifically excluded from the scope of this committee.

Represented at this organization meeting were some 50 companies covering a large segment of the chemical industry. Officers elected to guide the committee's activities include: chairman, Wayne A. Kirklin, Hercules Powder Co. vice-chairmen, E. G. Wiest, E. I. du Pont de Nemours & Co., Inc., and J. T. Woods, American Cyanamid Co.; secretary, R. C. Johnson, Manufacturing Chemists Assn.; members-at-large of the Executive Committee, A. Q. Butler, Malinkrodt Chemical Co. and B. H. Cummings, Shell Chemical Co.

Keen interest was expressed in a proposed program of work for the new committee, and it was agreed to establish projects immediately to develop temperature-density tables for a wide variety of organic liquids of commercial importance. This will supplement the extensive efforts along these lines in ASTM Committees D-2 on Petroleum Products and Lubricants and D-16 on Industrial Aromatic Hydrocarbons.

Other projects to be considered at the outset will be methods for analysis of functional groups and problems of acid-base titrimetry. The organizing group also took definite action to organize an executive subcommittee and four other subcommittees covering editorial matters, standards and reagents, precision and accuracy, and sampling. Later other subcommittees will be organized in two divisions—Division A, General Methods, covering elements, groups, properties, and techniques; and Division B, Product Methods, covering methods for specific products.



## Know Your Committee Officers

### Committee A-2 on Wrought Iron



**Chairman—L. S. Crane,**  
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## Steel Foundries Form Aircraft Castings Association

THE AIRCRAFT Castings Assn., a nonprofit corporation to promote the increased use of ferrous castings for the aircraft, missile, and related industries, has been formed by a group of leading steel foundries.

According to its first president, Allen M. Slichter, the objectives of the Association are to promote and develop an increased acceptance and use of ferrous castings, manufactured from nonexpendable patterns, among the aircraft, missile, and related industries;

to achieve and maintain uniform high standards of quality for its products; and to promote increased research and development of ferrous castings for aircraft, missile, and related applications.

Slichter states that the Association is a natural outgrowth of the increased demand for ferrous castings that meet the exacting requirements of the space age. Several leading steel castings suppliers felt that a coordinated effort was necessary to keep pace with rapidly changing industry conditions, and to broaden the knowledge and use of the unique advantages of the steel casting

processes. Present members of the Association include Electric Steel Foundry Co., Portland, Ore.; General Metals Corp., Oakland, Calif.; The Hanford Foundry Co., San Bernardino, Calif.; Lebanon Steel Foundry, Lebanon, Pa.; Pacific Alloy Engineering Corp., San Diego, Calif.; The Stanley Foundries, Inc., Huntington Park, Calif. and Symington-Gould Division of Symington Wayne Corp., DePew, N. Y.

Inquiries to the Association should be addressed to the secretary, W. W. Stevens, Jr., Stanley Foundries, Inc., 6009 Santa Fe Ave., Huntington Park, Calif.

## Proposed 60-Story Building to Use 42 ASTM Standards

THE NEW building planned for the head office of the Chase Manhattan Bank will be unique in New York City's downtown financial district. Sixty stories high, the building will be in a 2½-acre open plaza, affording plenty of light and air, in marked contrast to the prevailing pattern of narrow street canyons between tall buildings so characteristic of lower Manhattan.

The bank hopes to occupy the main building early in 1960. The entire project, including the plaza, is expected to be completed in 1962. Architects for the building are Skidmore, Owings, and Merrill, and the general contractor is the Turner Construction Co.

Of particular interest to the construction materials industry, materials engineer, and particularly to members of ASTM, is the long list of ASTM standards, shown below, specified for its construction. (Information regarding the ASTM specifications was furnished by the contractor.)

- A 7 Specifications for Steel for Bridges and Buildings
- A 15 Specifications for Billet-Steel Bars for Concrete Reinforcement
- A 47 Specifications for Malleable Iron Castings
- A 48 Specifications for Gray Iron Castings
- A 53 Specifications for Welded and Seamless Steel Pipe
- A 120 Specifications for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses
- A 123 Specifications for Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars, and Strip
- A 141 Specifications for Structural Rivet Steel
- A 164 Specifications for Electrodeposited Coatings of Zinc on Steel
- A 167 Specifications for Corrosion-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
- A 185 Specifications for Welded Steel Wire Fabric for Concrete Reinforcement
- A 207 Specifications for Rolled Wrought Iron Shapes and Bars
- A 233 Specifications for Mild Steel Arc-Welding Electrodes
- A 245 Specifications for Flat Rolled Carbon Steel Sheets of Structural Quality
- A 283 Specifications for Low and Intermediate Tensile Strength Carbon-Steel Plates of Structural Quality (Plates 2 in. and Under in Thickness)
- A 305 Specifications for Minimum Requirements for the Deformations of Deformed Steel Bars for Concrete Reinforcement

- A 307 Specifications for Steel Machine Bolts and Nuts and Tap Bolts
- A 325 Specifications for Quenched-and-Tempered Steel Bolts and Studs with Suitable Nuts and Plain Hardened Washers
- B 6 Specifications for Slab Zinc (Spelter)
- B 32 Specifications for Soft Solder Metal
- B 152 Specifications for Copper Sheet, Strip, Plate, and Rolled Bar
- C 28 Specifications for Gypsum Plasters
- C 31 Method of Making and Curing Concrete Compression and Flexure Test Specimens in the Field
- C 33 Specifications for Concrete Aggregates
- C 35 Specifications for Inorganic Aggregates for Use in Gypsum Plaster
- C 59 Specifications for Gypsum Molding Plaster
- C 73 Specifications for Sand-Lime Building Brick
- C 90 Specifications for Hollow Load-Bearing Concrete Masonry Units
- C 91 Specifications for Masonry Cement
- C 94 Specifications for Ready-Mixed Concrete
- C 126 Specifications for Ceramic Glazed Structural Clay Facing Tile, Facing Brick, and Solid Masonry Units
- C 129 Specifications for Hollow Non-Load-Bearing Concrete Masonry Units
- C 143 Method of Test for Slump of Portland Cement Concrete



- C 144 Specifications for Aggregate for Masonry Mortar
- C 145 Specifications for Solid Load-Bearing Concrete Masonry Units
- C 150 Specifications for Portland Cement
- C 161 Specifications for Mortar for Reinforced Brick Masonry
- C 207 Specifications for Hydrated Lime for Masonry Purposes
- C 220 Specifications and Methods of Test for Flat Asbestos-Cement Sheets
- C 240 Methods of Testing Structural Non-Load-Bearing Cellular Glass Blocks
- C 330 Specifications for Lightweight Aggregates for Structural Concrete
- D 43 Specifications for Creosote for Priming Coat with Coal-Tar Pitch in Dampproofing and Waterproofing

## OTHER SOCIETIES' EVENTS

- May 3-6—Air Conditioning and Refrigeration Institute, Annual Meeting, The Homestead, Hot Springs, Va.
- May 3-7—The Electrochemical Society, National Meeting, Sheraton Hotel, Philadelphia, Pa.
- May 4-6—American Society for Metals, Southern Metals Conference, Bon Air Hotel, Augusta, Ga.
- May 4-6—Construction Specifications Institute, 3rd Annual Convention, Palmer House, Chicago, Ill.
- May 6-8—American Institute of Chemists, 36th Annual Meeting, Hotel Traymore, Atlantic City, N. J.
- May 11-15—American Welding Society, Inc., Annual National and Welding Show, Statler Hotel, Buffalo, N. Y.
- May 12-14—Association of American Railroads, 35th Annual Session of the Communications Section, Netherland-Hilton Hotel, Cincinnati, Ohio.
- May 13-15—National Industrial Sand Assn., Annual Meeting, The Homestead, Hot Springs, Va.
- May 14-16—Acoustical Society of America, Spring Meeting, Chateau Laurier, Ottawa, Ont., Canada.
- May 14-16—American Institute of Industrial Engineers, 10th Annual National Conference and Convention, Biltmore, Atlanta, Ga.
- May 17-21—The American Ceramic Society, Annual Meeting, Palmer House, Chicago, Ill.
- May 18-19—Society of American Military

Engineers, National Convention, Washington, D. C.

May 18-20—Instrument Society of America, 5th Annual Symposium on Instrumental Methods of Analysis, Shamrock-Hilton Hotel, Houston, Tex.

May 20-22—Society for Experimental Stress Analysis, National Spring Meeting, Sheraton Park Hotel, Washington, D. C.

May 25-26—Malleable Founders' Society, Annual Meeting, The Homestead, Hot Springs, Va.

May 25-27—American Society for Quality Control, Annual Meeting, Cleveland Hotel, Cleveland, Ohio.

May 25-29—National Fire Protection Assn., Annual Meeting, Atlantic City, N. J.

May 27-30—American Petroleum Institute, Division of Refining, 24th Mid-year Meeting, Statler Hotel, New York, N. Y.

June 1-4—American Association of Spectrographers, 10th Annual Symposium on Spectroscopy, Conrad Hilton Hotel, Chicago, Ill.

June 1-5—5th World Petroleum Congress & Exposition, Coliseum, New York, N. Y.

June 4-7—Society of Women Engineers, National Convention, Chase Hotel, St. Louis, Mo.

June 7-10—National Association of Purchasing Agents, New York, N. Y.

# An Improved 8-Hydroxyquinoline Method for the Determination of Magnesium Oxide in Portland Cement

By H. A. BERMAN

The Federal Optional Method and ASTM optional 8-hydroxyquinoline method for determining magnesium oxide in portland cement usually give high values, poor reproducibility between operators, and excessive specification "failures." These methods have been studied under various precipitation conditions. A double precipitation method has been investigated and found equal in reproducibility and accuracy to the referee ammonium phosphate method and to be considerably faster. It is therefore suggested as a replacement for the current referee method.

THE Federal<sup>1</sup> and ASTM<sup>2</sup> specifications for most types of portland cement limit the magnesium oxide content to 5.0 per cent to help control the soundness of mortar and concrete. Both specifications employ the ammonium phosphate method (referee) for determining MgO.<sup>3,4</sup> However, because this determination takes several days, an optional rapid volumetric method<sup>4</sup> using 8-hydroxyquinoline is permitted, provided the cement meets the specification requirement.

Several portland cements have shown a tendency to skirt the MgO limit. Often, considerable time has been lost in releasing cement shipments when samples that failed to meet the specification by the optional method were found to pass when analyzed by the referee method.

In general, the optional method has consistently given higher results than the referee method, at the 4 to 5 per cent level of MgO. Reasons for this discrepancy have been investigated and a refinement of the 8-hydroxyquinoline procedure has been developed that is as accurate as the referee method and considerably faster. The improvement consists of a double precipitation of the magnesium with 8-hydroxyquinoline, in which the quantities of precipitant added are independent of the MgO

content of the sample. After the preliminary separation of  $\text{SiO}_2$ ,  $\text{R}_2\text{O}_3$ ,  $\text{Mn}_2\text{O}_3$ , and  $\text{CaO}$ , six determinations of magnesium by the recommended procedure can be completed in 2.5 hr. The detailed procedure follows.

## RECOMMENDED PROCEDURE

### Reagents

#### 8-Hydroxyquinoline Solution

Dissolve 25 g of 8-hydroxyquinoline in 60 ml of glacial acetic acid. When solution is complete, dilute to 2 liters with cold water. One ml of this solution is equivalent to approximately 0.0017 g of MgO.

#### Standard Sodium Thiosulfate Solution (0.1N)

Dissolve 25 g of  $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$  in 200 ml of water and dilute to 1 liter. It is well to let the solution stand at least a week before standardization. Standardize this solution directly against  $\text{K}_2\text{Cr}_2\text{O}_7$ , or on sodium oxalate through a  $\text{KMnO}_4$  solution, or on  $\text{As}_2\text{O}_3$  through a solution of resublimed iodine (Standard samples Nos. 136a, 40g, and 83b of the National Bureau of Standards are convenient for this purpose). One ml of exactly 0.1N  $\text{Na}_2\text{S}_2\text{O}_3$  is equivalent to 0.000504 g of MgO.

#### Standard Potassium Bromate—Potassium Bromide Solution (0.2N)

Dissolve 20 g of  $\text{KBr}$  and 5.57 g of  $\text{KBrO}_3$  in 200 ml of water and dilute to 1 liter. Obtain the ratio of the strength of this solution to that of the standard  $\text{Na}_2\text{S}_2\text{O}_3$  solution as follows: to 200 ml of water in a 500-ml Erlenmeyer flask, add exactly 25 ml of the standard  $\text{KBrO}_3$ - $\text{KBr}$  solution. Add 20 ml of  $\text{HCl}$ , stir, and add immediately 10 ml of  $\text{KI}$  (250 g per liter). Mix well

and titrate at once with the  $\text{Na}_2\text{S}_2\text{O}_3$  solution until nearly colorless. Add 2 ml of starch solution, and titrate to the disappearance of the blue color. Calculate the ratio in strength of the standard  $\text{KBrO}_3$ - $\text{KBr}$  solution to the standard  $\text{Na}_2\text{S}_2\text{O}_3$  solution by dividing the volume of  $\text{Na}_2\text{S}_2\text{O}_3$  solution by the volume of  $\text{KBrO}_3$ - $\text{KBr}$  solution used in the titration.

### Starch solution

To 500 ml of boiling water add a cold suspension of 5 g of soluble starch in 25 ml of water. Cool, and add a cool solution of 5 g of  $\text{NaOH}$  in 50 ml of water. Add 15 g of  $\text{KI}$ , and mix thoroughly.

### Standard MgO Solution (1 ml = 0.1 per cent MgO)

Ignite enough analytical reagent grade MgO in a tared crucible at 1000 C to give an ignited weight of 0.5 g, and weigh to the nearest 0.1 mg. Dissolve in a few ml of distilled water and a few ml of  $\text{HCl}$ . Transfer to a 1-liter volumetric flask. Dilute to the mark.

### Procedure

Acidify the combined filtrates, reserved in the determination of  $\text{CaO}$  with  $\text{HCl}$  and adjust the volume to 400 ml, concentrating by evaporation if necessary. Heat the solution to 70 C, make it just ammoniacal with  $\text{NH}_4\text{OH}$ , and add 30 ml of the 8-hydroxyquinoline reagent. Place on a mechanical stirring machine and add 18 ml  $\text{NH}_4\text{OH}$  (4 ml per 100 ml solution).

Stir for 30 min. If only a small quantity of precipitate appears after 15 min, add by pipet 20 or 25 ml of the standard MgO solution and stir for 30 min more. Filter without delay through a medium-texture paper and wash several times with hot  $\text{NH}_4\text{OH}$  (1-40). It is not necessary to police the beaker.

Place the beaker, in which the precipitation was made, under the funnel and dissolve the precipitate on the filter paper in 50 to 75 ml hot  $\text{HCl}$  (1-9). Make the solution just ammoniacal to methyl red, add hot water to a total volume of 400 ml, and add from a pipet 1 ml of the 8-hydroxyquinoline reagent. Place on the mechanical stirring machine, add 16 ml  $\text{NH}_4\text{OH}$ , and stir for 30 min. Filter as

**NOTE.—DISCUSSION OF THIS PAPER IS INVITED,** either for publication or for the attention of the author. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

<sup>1</sup>Cements, Portland (SS-C-192b), Federal Specification, July 2, 1956.

<sup>2</sup>Specification for Portland Cement (C150-56), 1958 Book of ASTM Standards, Part 4.

<sup>3</sup>Methods of Chemical Analysis of Portland Cement (C 114-58), 1958 Book of ASTM Standards, Part 4 (Magnesium Oxide, sections 14, 15); Magnesium Oxide, Optional Method C, sections 39, 40; Calcium Oxide, section 13 (b).

<sup>4</sup>Cements, Hydraulic, Sampling, Inspection, and Testing (Standard No. 158) Federal Test Method, May 1, 1957 (Magnesium Oxide, method 1101, paragraph 5; Magnesium Oxide, method 1111, paragraph 5).

\*Footnote 3, footnote 4, method 1101, paragraph 4, section 13 (b) Calcium Oxide.

HORACE A. BERMAN, physical chemist with the Concreting Materials Section of the National Bureau of Standards, has been engaged since 1940 in testing and in the development of methods of tests for such building materials as portland cement and organic coatings. He is currently involved in research on the properties of compounds in portland cement.





before on a new filter paper without delay and wash thoroughly with hot  $\text{NH}_4\text{OH}$  (1-40), this time policing the beaker. Wash off the outside of the funnel stem and place a 500-ml Erlenmeyer flask under the funnel. Dissolve the precipitate on the filter paper in 50 to 75 ml of hot HCl (1-9), dilute the resulting solution to 200 ml and add 15 ml of HCl.

Cool the solution to 25 C (not cooler) and add the standard  $\text{KBrO}_3\text{-KBr}$  solution from a buret with constant swirling, until about a 5 to 10 ml excess has been added (see NOTE below). Allow to stand for about 30 sec to insure complete bromination. Add 10 ml of KI (250 g per liter). Stir the resulting solution for about 10 sec and then titrate with the standard  $\text{Na}_2\text{S}_2\text{O}_3$  solution until the color of the iodine becomes faintly yellow. At this point add 2 ml of the starch solution and titrate the solution to the disappearance of the blue color.

NOTE.—The amount of the standard  $\text{KBrO}_3\text{-KBr}$  solution used may be as follows:

Approximate content of MgO, per cent, including any added MgO	Amount of standard $\text{KBrO}_3\text{-KBr}$ solution, ml
2 to 3.....	20
3 to 4.....	25
4 to 5.....	30
5 to 6.....	35

If the approximate MgO content is not known, it can be estimated for purposes of the  $\text{KBrO}_3\text{-KBr}$  addition from the depth of color in the filtrate from the first precipitation. The deeper the color, the lower the MgO content.

#### Blank

Make a blank determination, using the same amounts of reagents, and correct the result obtained in the analysis accordingly. Normally, the blank will contain little or no MgO. Therefore, the complete procedure for low-MgO cement must be followed, in which standard MgO solution is added by pipet to the solution in which the precipitation with 8-hydroxyquinoline is made. This addition may be made before mechanical stirring is started instead of after 15 min of stirring. The amount of  $\text{KBrO}_3\text{-KBr}$  solution added in the titration should be 10 or 12.5 ml (for MgO additions of 2 or 2.5 per cent, respectively) plus an additional amount equal to half the quantity of  $\text{Na}_2\text{S}_2\text{O}_3$  solution used for titrating the sample, to approximate the conditions in the sample during the titration. The blank is usually of the order of 0.02 per cent MgO.

<sup>6</sup> The boldface numbers in parentheses refer to the list of references appended to this paper.

<sup>7</sup> The standard deviation,  $\sigma$ , is calculated as described in ASTM Manual on Quality Control of Materials, Am. Soc. Testing Mats., p. 14, Jan. 1951. (Issued as separate publication ASTM STP No. 15-C).

$$\sigma = \sqrt{\frac{\sum(x^2)}{n} - \bar{x}^2}$$

where  $x$  is an individual determination,  $\bar{x}$  is the mean, and  $n$  is the number of determinations. The standard deviation of the mean used here is  $\sigma/\sqrt{n}$ .

#### Calculation

Calculate the percentage of MgO in the sample and in the blank as follows:

$$\text{MgO, per cent} = E(V_1R - V_2) \times \frac{100}{200 - LP}$$

where:

$E$  = MgO equivalent of the  $\text{Na}_2\text{S}_2\text{O}_3$  solution, g per ml,

$V_1$  =  $\text{KBrO}_3\text{-KBr}$  solution used, ml,

$R$  = ratio in strength of the  $\text{KBrO}_3\text{-KBr}$  solution to the  $\text{Na}_2\text{S}_2\text{O}_3$  solution,

$V_2$  =  $\text{Na}_2\text{S}_2\text{O}_3$  solution used, ml,

$L$  = standard MgO solution added during the precipitation if any, ml, and

$P$  = MgO equivalent of the standard MgO solution, per cent MgO per ml, or grams MgO per liter divided by 5.

Subtract the calculated percentage of MgO for the blank from the calculated percentage for the sample.

### EXPERIMENTAL

#### Existing Specification Methods

In the optional method<sup>4</sup>, proposed originally by Redmond and Bright (1, 2)<sup>6</sup>, the magnesium, after removal of  $\text{SiO}_2$ ,  $\text{R}_2\text{O}_3$ , and precipitation of calcium as the oxalate, is separated by 8-hydroxyquinoline in strongly ammoniacal solution. The volume of reagent added is based on the quantity of MgO expected. The solution is stirred mechanically 15 min and filtered. The precipitate of magnesium oxyquinolate is washed with hot  $\text{NH}_4\text{OH}$  (1-40), dissolved in dilute HCl and the acid solution titrated with standard  $\text{KBrO}_3$ .

In the referee method<sup>3,4</sup>, the magnesium, after removal of  $\text{SiO}_2$ ,  $\text{R}_2\text{O}_3$ ,  $\text{Mn}_2\text{O}_3$ , and CaO, is twice precipitated with ammonium phosphate and ignited to magnesium pyrophosphate at 1100 to 1200 C. The precipitates have been ignited in this laboratory at gradually rising temperature to a maximum of 1100 C.

Some of the differences in the values obtained for MgO by the two methods are associated with separations prior to the precipitation of the magnesium. The fact that manganese is removed in the referee procedure, but not in the optional procedure, is one source of high results by the optional method. This effect is opposed, but usually not balanced, by the loss of some magnesium in the single precipitation of CaO employed in the optional method.

The high results consistently obtained in the optional method, and the poor reproducibility among different operators, are attributable to the MgO determination proper, as confirmed by high results obtained with standards made from reagent magnesium salts and with a cement low in manganese.

#### Apparatus and Standards

##### Apparatus

The only special apparatus required was a mechanical stirrer capable of accommodating six samples during the precipitation.

##### Standards

**Pure  $\text{Mg}^{++}$  Standard.**—Pure  $\text{Mg}^{++}$  standard solutions were prepared from reagent grade  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ ,  $\text{MgCO}_3$  ignited, and MgO ignited. Each of these was dissolved in a dilute HCl solution and made up to a concentration of approximately 0.5 MgO per liter, accurately known. No difference in results was observed between solutions made from the different magnesium compounds used. The MgO in the solution made from ignited MgO was determined by the phosphate method, using aliquots containing 0.0213 g MgO (equivalent to 4.26 per cent for a 0.5-g cement sample), to which 30 ml 5 per cent ammonium oxalate solution and 50 ml HCl had been added. The MgO found by the phosphate method was 4.25 and 4.27 per cent.

**Standard Cement Sample.**—A high-MgO cement was used with the following analysis, determined by referee methods:  $\text{SiO}_2$  21.52 per cent;  $\text{R}_2\text{O}_3$  7.44 per cent; CaO 62.38 per cent;  $\text{SO}_3$  1.88 per cent; loss on ignition 2.15 per cent;  $\text{Mn}_2\text{O}_3$  0.05 per cent; MgO 4.26 per cent. The figure for MgO was the mean of seven determinations: 4.32, 4.25, 4.30, 4.28, 4.23, 4.23, 4.23; mean,  $4.26 \pm 0.013$  (standard deviation of the mean).<sup>7</sup>

#### Single Precipitation of Magnesium

In an attempt to secure better accuracy and reproducibility with the optional method, the single precipitation of MgO with 8-hydroxyquinoline was first studied, both with pure  $\text{Mg}^{++}$  solutions and with the standard cement. The following conditions of the optional procedure were varied to observe their effect: (a) time of stirring, (b) quantity of 8-hydroxyquinoline reagent added, and (c) volume of solution used during the precipitation.

The values obtained for MgO (5 per cent MgO level) on a standard MgO solution, when precipitation conditions were varied, are shown in Table I. Time of stirring had no apparent effect after 20 min. The 15-min periods called for in the specifications sometimes gave low results unless more than 15 ml reagent was used. There was also no noticeable difference between the time of stirring necessary on the two different types of stirring machines used in this work. It may be concluded, therefore, that time of stirring is significant only

as a limiting factor.

The greatest changes in the results took place when the quantity of reagent added and the volume of solution were varied. Increase in reagent volume caused a significant rise in per cent MgO obtained, whereas an increase in solution volume caused a slight drop.

The same trend can be observed in Table II for the single precipitation of MgO on the standard cement, in the filtrate from a double precipitation of CaO. The determinations indicated in Table II were made only at the 4.26 per cent MgO level, with a constant column of 400 ml. Table III shows similar single precipitations of MgO in the 0.5 to 5 per cent range, from pure  $Mg^{++}$  solutions to which 36 ml of a 5 per cent ammonium oxalate solution and 40 ml of HCl were added, to simulate the composition of a CaO filtrate from a cement. In these oxalate-rich solutions, and in the cement filtrates, precipitates formed more slowly than in the oxalate-free solutions.

Although the optional specification method gave high results for most MgO levels, results were low at MgO levels less than 1 per cent. Thus, the MgO content of the solution also is a factor in determining the errors of the single precipitation.

When CaO is not determined, the specifications permit precipitation of MgO with 8-hydroxyquinoline after precipitation of the CaO, without removal of the solid calcium oxalate. The belief has been expressed that the calcium oxalate crystals, by providing a surface to initiate quinolate crystal formation, can correct the low results obtained in the low-MgO range. Table III shows that the addition of a slurry of calcium oxalate during the precipitation did not improve the results for a solution containing 0.50 per cent MgO.

Miller and McLennan (3) state that high results were obtained if 8-hydroxyquinoline was added before the excess of  $NH_4OH$ , but results were more accurate if the order of addition was reversed and the reagent added slowly with constant stirring until a deep yellow color showed that the addition was sufficient. The effect of reversing the order was studied, without their technique of slow addition. The results, in Tables II and III show no significant change at any MgO level except 1 per cent, where the values were low. Within the scatter of any of these determinations, the reverse order of addition is essentially a duplication of the normal order.

The critical factors then are volume of reagent, volume of solution, and per cent MgO present. The effects of these variables can be studied by a mathe-

TABLE I.—PER CENT MgO FOUND IN SINGLE PRECIPITATIONS, WITH PURE  $Mg^{++}$  SOLUTION.  
MgO Taken = 4.98 per cent.

ml	$R^a$	MgO Found, per cent				
		200 ml Solution	300 ml Solution	400 ml Solution	500 ml Solution	600 ml Solution
15	5.70	...	5.03 (15) <sup>b</sup>	4.89 (15) <sup>b</sup>	4.91 (15) <sup>b</sup>	4.96 (15) <sup>b</sup>
		...	5.02 (20)	4.96 (20)	4.97 (20)	4.96 (15)
		...	5.02 (20)	5.01 (25)	5.01 (20)	...
		...	...	5.00 (30)	4.97 (20)	...
		...	...	4.96 (40)	4.96 (25)	...
20	7.60	...	...	...	5.10 (15)	5.05 (20)
		...	...	...	5.08 (20)	...
25	9.50	5.45 (20) <sup>b</sup>	5.28 (20)	5.12 (20)	5.07 (20)	5.05 (20)
		...	...	...	5.06 (20)	...
		...	...	...	5.17 (20)	...
		...	...	...	5.17 (20)	...
		...	...	...	...	...
40	14.00	...	...	5.30 (30)	...	...

<sup>a</sup>  $R$  = Per cent MgO stoichiometrically equivalent to total 8-hydroxyquinoline reagent added;  $R$  varies with the reagent batch used.

<sup>b</sup> Figures in parentheses represent stirring time in minutes.

TABLE II.—PER CENT MgO FOUND IN THE LOW-MANGANESE CEMENT. CaO DOUBLE-PRECIPITATED.

Total volume = 400 ml, Stirring time = 30 min. except where noted. Per cent MgO =  $4.26 \pm 0.013$ , by phosphate method.

8-Hydroxyquinoline Reagent Volume Added, ml		MgO Found, per cent			
First Precipitation	Second Precipitation	By Single Precipitation		By Double Precipitation	
			Error		Error
40.....	...	4.27	+0.39	4.28*	+0.02
40.....	1	...	...	...	...
30.....	...	4.52	+0.26	4.27*	+0.01
30.....	1	...	...	...	...
25.....	{ ...	4.42	+0.16	...	...
25.....	{ ...	4.39	+0.13	...	...
25.....	{ ...	4.37 <sup>b</sup>	+0.11	...	...
25.....	{ 1	...	...	4.28*	+0.02
25.....	{ 1	...	...	4.24*	-0.02
25.....	{ 1	...	...	4.26*	0.00
25.....	{ 1	...	...	4.23 <sup>b</sup>	-0.03
25.....	{ 1	...	...	4.23 <sup>c</sup>	-0.03
25.....	{ 0	...	...	4.19	-0.07
25.....	{ 0	...	...	4.26	0.00
20.....	2	4.29	+0.03	4.19	-0.07
20.....	1.5	...	...	4.31	+0.05
20.....	{ 1	...	...	4.19	-0.07
20.....	{ 1	...	...	4.24	-0.02
20.....	{ 0	...	...	4.18	-0.08
20.....	{ 0	...	...	4.26	0.00
15.....	{ 2	...	...	4.11	-0.15
15.....	{ 2	...	...	4.08	-0.18

<sup>a</sup> Double-precipitations in the upper half of this table (above the double line) followed (or closely bracketed) the procedure recommended in this paper. The mean and standard deviation of the mean for these determinations is  $4.27 \pm 0.006$ .

<sup>b</sup> Stirring period 20 min (1st precipitation), 20 min (2d precipitation), for the double precipitation).

<sup>c</sup> Stirring period 30 min (1st precipitation), 15 min (2d precipitation).

matical treatment of the data, which will be presented in a subsequent publication. It has been possible to make rough predictions of the error to be expected in the precipitation under various conditions, with the aid of approximate equations developed thus far. From this mathematical treatment, or simply from the data presented, it should be possible to select certain conditions which will yield an accurate

result, by balancing the positive errors due to excess reagent addition against the negative errors caused by slow or incomplete precipitation due to insufficient reagent excess or large concentrations of oxalate ion. It may even be possible to choose a set of conditions such that the loss of MgO in a single precipitation of CaO will be balanced by the positive error of the single precipitation of MgO. The conditions necessary

for this balance can vary from operator to operator. The proper choice of conditions depends as well on advance knowledge of the MgO content of a particular sample. Although the MgO content of a particular brand of cement is often steady, it has been known to change unexpectedly. Because of these uncertainties, it is not practical to adjust the variables of a single precipitation with 8-hydroxyquinoline to obtain an accuracy equal to that of the referee method.

Miller and McLennan's (3) method of slowly adding 8-hydroxyquinoline to a strongly ammoniacal and very concentrated solution of the sample is not suitable for routine analysis because it requires low volumes, attained only by time-consuming evaporation.

However, as will be shown later under Double Precipitation of Magnesium, it has been possible to obtain results which are as accurate and reproducible as the current referee method, with a double precipitation of MgO with 8-hydroxyquinoline. With this procedure it is not necessary to know the MgO range of the sample in advance.

#### Double Precipitation of Magnesium

Since the oxalate concentration has some effect on the precipitation of magnesium quinolate, all first precipitations were made only in oxalate-rich solutions. Determinations were made on the low-manganese cement (on filtrates from double precipitations of CaO) to cover the 4 per cent level; and on pure Mg<sup>++</sup> solutions to which 36 ml of 5 per cent ammonium oxalate solution and 40 ml of HCl were added, to cover the 0.5 to 3 and the 5 per cent ranges.

The volume of the solutions was kept at 460 ml in all these tests because this is very close to the volume of filtrates from double precipitations of CaO and because there were no significant effects of volume in the single precipitation tests for volumes of 400 ml and higher (see Table I). Reagent volume for the first precipitation was varied between 15 and 40 ml, and for the second precipitation between 0 and 2 ml (to keep the number of runs to a minimum, first-approximation combinations of these reagent volumes that would give zero error for MgO were chosen from the rough mathematical treatment which has been discussed under Single Precipitation of Magnesium.

Double precipitations of the oxalate-rich Mg<sup>++</sup> solutions are listed in Table III. Double precipitations on the standard cement are listed in Table II.

#### Synthetic Cement Filtrates

Table III shows that the recommended procedure (runs boxed in

TABLE III.—PER CENT MgO FOUND IN PURE Mg<sup>++</sup> SOLUTIONS CONTAINING AMMONIUM OXALATE.

Total volume = 400 ml Stirring time = 30 min except where noted.

MgO Taken, per cent	Reagent Volume Added, ml		Per Cent MgO Found			
	First Precipitation	Second Precipitation	By Single Precipitation	Error	By Double Precipitation	Error
5.05.....	40	{ ...	5.40	+0.35	...	...
		{ ...	5.49	+0.44	...	...
		{ ...	5.55	+0.50	...	...
	40	{ 1	...	...	5.14	+0.09
	30	{ 1	...	...	5.06	+0.01
		{ ...	5.52	+0.47	...	...
	30 <sup>a</sup>	{ 1	...	...	5.06	+0.01
		{ 1	...	...	5.02	-0.03
		{ 1	...	...	5.06 <sup>b</sup>	+0.01
		{ 1	...	...	5.04 <sup>b</sup>	-0.01
	25	{ ...	5.18 <sup>c</sup>	+0.13	...	...
	25	{ 1	...	...	5.06	+0.01
3.03.....	30	{ ...	3.29	+0.26	...	...
		{ ...	3.31 <sup>b</sup>	+0.28	...	...
		{ ...	...	...	...	...
	30	{ 1	...	...	3.06	+0.03
		{ 1	...	...	3.04	+0.01
		{ 1	...	...	3.05	+0.02
		{ 1	...	...	3.05 <sup>b</sup>	+0.02
	25	{ 1	...	...	3.05 <sup>b</sup>	+0.02
		{ 1	...	...	3.05 <sup>b</sup>	+0.02
		{ 1	...	...	3.01	-0.02
		{ 1	...	...	2.93	-0.10
	25	{ 1	...	...	3.01	-0.02
		{ 1	...	...	2.98 <sup>c</sup>	-0.05
1.99.....	30	{ ...	2.18	+0.19	...	...
		{ ...	2.18 <sup>b</sup>	+0.19	...	...
		{ ...	2.05 <sup>d</sup>	+0.06	...	...
	30	{ 1	...	...	1.84 <sup>b</sup>	-0.15
		{ 1	...	...	1.98	-0.01
		{ 1	...	...	1.98 <sup>d</sup>	-0.01
	25	{ 1	...	...	1.99 <sup>e</sup>	0.00
		{ ...	2.12	+0.13	...	...
		{ ...	2.11	+0.12	...	...
	25	{ 1	...	...	1.94 <sup>b</sup>	-0.05
		{ 1	...	...	1.90	-0.09
		{ 1	...	...	1.65 <sup>c</sup>	-0.34
		{ 1	...	...	1.66 <sup>b,c</sup>	-0.33
0.99.....	30	{ ...	1.06	+0.07	...	...
		{ ...	0.92 <sup>b</sup>	-0.07	...	...
		{ ...	1.02 <sup>d</sup>	+0.03	...	...
	30	{ 1	...	...	0.91	-0.08
		{ 1	...	...	0.81 <sup>b</sup>	-0.18
		{ 1	...	...	0.94 <sup>d</sup>	-0.05
	30	{ 1	...	...	1.01 <sup>e</sup>	+0.02
		{ ...	1.33 <sup>e</sup>	+0.34	...	...
		{ ...	...	...	...	...
	30	{ 1	...	...	0.40	-0.10
		{ 1	...	...	0.39 <sup>b</sup>	-0.11
		{ 1	...	...	0.36 <sup>d</sup>	-0.14
		{ 1	...	...	0.83 <sup>e</sup>	+0.33
0.50.....	30	{ 1	...	...	0.06 <sup>d</sup>	-0.44
		{ 1	...	...	0.49 <sup>e</sup>	-0.01

<sup>a</sup> With the minor variations noted in footnotes <sup>b</sup> and <sup>d</sup>, the boxed runs followed the procedure recommended in this paper.

<sup>b</sup> NH<sub>4</sub>OH added before the 8-hydroxyquinoline.

<sup>c</sup> Stirring time 20 min (1st precipitation), 15 min (2d precipitation, for double precipitations).

<sup>d</sup> Calcium oxalate slurry added.

<sup>e</sup> Magnesium addition-technique used.

broken lines) is accurate within  $\pm 0.03$  per cent MgO at the 5, 3, and 2 per cent levels, considerably more accurate than the single-precipitation procedure, and at least as good as the phosphate procedure (see below under Low-Manganese Cement). If the reagent quantity in the first precipitation is varied just above or below the recommended 30 ml, some determinations are still accept-

able, while others show larger errors.

The accuracy of the recommended procedure in the 2 to 5 per cent range has been extended to MgO levels below 2 per cent by the fast and convenient method of adding a known amount of Mg<sup>++</sup> to the solution to be precipitated, thereby bringing it within the 2 to 5 per cent range. The analyst can do this if he detects indications of a low MgO



content during the determination by the speed of precipitation. A trial with two solutions each of 2, 1 and 0.5 per cent MgO, showed the following rates: within 10 min, both 2 per cent samples had begun to precipitate; by 15 min, one of the 1 per cent solutions showed some turbidity, the other none; and the 0.5 per cent solutions were still clear at that time. If the operator adds 2 or 2.5 per cent MgO to any solutions that show only a small precipitate after 15 min, all samples are brought within the 2 to 5 per cent range. The double precipitations labeled with footnote \* in Table III show that this method is reliable for an original 0.5 to 2 per cent content.

#### Low-Manganese Cement

The average of seven determinations of the MgO content of the low-manganese cement by the referee phosphate method was  $4.26 \pm 0.013$  per cent. Five determinations which followed or closely bracketed the recommended 8-hydroxyquinoline procedure gave a mean of  $4.27 \pm 0.006$  per cent.<sup>7</sup> The maximum spread in the phosphate determination was 0.09, and the maximum spread in the recommended procedure was 0.04. A similar compilation of phosphate determinations of MgO

made by Ingram and Bean (5) showed a total spread of 0.09 per cent MgO when manganese was removed by the bromine-ammoniacal method and 0.08 when removed by the  $\text{KMnO}_4$  method. For portland cement at the 4 per cent level, the recommended procedure is as accurate and reproducible as the referee phosphate procedure.

#### Necessary Precautions

Several precautions must be taken in the titration. A blank must be run as directed under The Recommended Procedure, and the titration of this blank must duplicate the conditions of the sample titration. It is believed that the major source of the observed blank error (0.02 per cent in this series of determinations) lies in the volatility of bromine in the titration. If a  $\text{KBrO}_3$ - $\text{KBr}$  excess of about 5 ml is used for a sample, this should be the excess added to the blank, to equate bromine loss in sample and blank. It is also desirable to give the excess bromine sufficient time to react completely with the KI before adding thiosulfate solution; otherwise, high results may be obtained.

Another source of positive error is the tendency of titration solutions to form a precipitate (probably containing some free iodine) when KI is added. After a pseudo-end point is reached, the precipitate dissolves slowly and requires additional titration. This occurs when the solution is too cold or too concentrated. The effect will be minimized by maintaining proper temperature and proper dilution during the titration, as prescribed in the method.

#### CONCLUSIONS

The double-precipitation procedure recommended in this paper is suggested as a referee method for the determination of MgO in portland cement. Not only is it as reliable and reproducible as the ammonium phosphate referee procedure, but it is also considerably faster.<sup>8</sup>

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- (3) C. C. Miller and I. C. McLennan, "8-Hydroxyquinoline as a Reagent for the Determination of Magnesium, Especially in Carbonate and Silicate Rocks," *Journal*, Chemical Soc. (London), p. 656 (1940).
- (4) I. M. Kolthoff and E. B. Sandell, *Textbook of Quantitative Inorganic Analysis*, p. 362, Third Edition (1952).
- (5) B. L. Ingram and L. Bean, "Removal of Manganese Prior to Calcium and Magnesium Precipitations," *Analytical Chemistry*, Vol. 25, p. 1217 (1953).

\*A double precipitation is not recommended for inclusion in the optional method because it may lead to low results due to loss of MgO in the prior separations. It is suggested, however, that the optional method be modified to include the technique of addition of standard MgO solution, for cements containing less than 2 per cent MgO, as described in the Recommended Procedure.

## Physical Changes in Setting Gypsum Plaster

By B. M. O'KELLY

The object of the reported work was the study of physical changes in a setting plaster mass including exchanges and equilibria between the solid and liquid phases. Studied were: (a) variations in the suction of the mass to free water; (b) water sorption; (c) variations in apparent volume. Water sorption studies showed the initial presence of water in excess of saturation requirements and that water sorbed closely approximated the amount required to fill emptied pores. As a result of these considerations it is suggested that plaster hardening involves only mechanical interaction of growing gypsum crystals. How the consolidation mechanism results in apparent volume changes and suction development is shown. Development of a logical concept of the sequence of physical changes in the setting mass is attempted.



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THE work reported in this paper comprises the results of tests designed to provide information regarding the physical changes taking place in setting plaster and the changes in the characteristics of the mass toward free water. Where possible the tests used were carried

out simultaneously on three samples of a single batch of plaster and water. The tests used were: (a) determination of volume changes, (b) measurement of the amount of freely available water sorbed by the plaster; and (c) measurement of the tendency of the plaster to

sorb water when no water was, in fact, allowed to be imbibed. For convenience, the test results, in so far as this was feasible, are reported individually and are then considered collectively in a final section. For the tests a pottery plaster was used (a gypsum plaster formulated for use by the ceramic industry in the preparation of absorbent slip-casting molds). A mix ratio of 2 parts plaster to 1 part water, by weight, was used throughout. The mixing procedure consisted of adding the plaster to the water at 0 sec, spreading it over the surface of the water with the mixing beaters from 5 to 10 sec., inserting the beaters at 10 sec and mixing until 40 sec had elapsed. All time periods in this paper are measured from start of mixing.

The following relationships will be referred to in the paper:

	$\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O} + \frac{1}{2}\text{H}_2\text{O} = \text{CaSO}_4 \cdot 2\text{H}_2\text{O}$		
Weight, g.....	145.00	27.0	172.00
Absolute specific gravity.....	2.75	1.0	2.32
Absolute molecular volume, cu cm.....	52.73	27.0	74.14
	79.73		74.14

Decrease in absolute volume = 5.59  
 Per cent increase in solid volume (on  $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$ ) =  $\frac{21.41}{52.73} \times 100$  per cent  
 = 40.60 per cent

Decrease (cu cm) in absolute volume per g of gypsum =  $\frac{5.59}{172}$   
 = 0.033 cu cm

## Previous Work

Only in the field of volume change has work been reported (1,2,3,4,5,6,7).<sup>1</sup> These references are believed to be the more important contributions in this field but do not comprise a complete list.

The techniques reported for volume measurement fall into three classes. The most widely used technique (2, 5,6,7) was that of confining the plaster in a container having one movable wall, the movement of the wall mirroring the volume change and being observed by a suitably sensitive method. Reference (4) is typical of a technique which involves the filling of a rigid container with plaster and embedding in the plaster a flexible container filled with water. The flexible container is connected by a

rigid tube to a graduated tube, and the volume change in the plaster registers as a change in level of the water in the graduated tube. Finally, the technique reported by Murray (3) restrains a plaster mass as little as possible consistent with preventing flow, and measures volume change by observing the movement of reference points floating on the plaster. After study, the most valuable contributions are believed to be in references (2,3,5,6,7) of which (5) is outstanding.

It is worth noting that the movable wall technique works best when the movable wall constitutes the lid of a tall slender flexible container. However, in this arrangement, the results obtained are difficult to interpret. While the plaster is fluid, as it is in the initial stages, the movement of the measuring wall is a function of the volume change of the plaster. When the plaster has achieved a rigid structure the movement of the sensing wall may more nearly represent a linear dimensional change. The measurements obtained in the period between the fluid and the solid states may be difficult to interpret.

Chassevent (5), when invited to comment on this point, replied that he believed his apparatus (a rubber tube capped with a sensing element) measured true volume expansion only when the plaster was covered with water, since in this case the initial contraction was prevented by penetration of water into any pores formed, and stated that "... swelling... is followed and measured during 95 to 98 per cent of the hydration of the plaster."

When the plaster is not covered with water, Chassevent believes that results obtained are comparative only being due to "... two phenomena acting in inverse senses: the decrease in absolute volume and the increase in apparent volume."

## Suction Development

The surface of a solid which is wetted by water possesses the property of holding water molecules and thereby lowering their free energy level below that of bulk water. This situation produces a free energy gradient between the solid and any bulk water available to it, and a transfer of water molecules will occur from the bulk water to the surface of the solid. This transfer will continue until the final layers of held water molecules possess virtually the free energy of bulk water molecules.

If the solid is present in the form of small solid particles, some or all of which are close together, the layer of water held on one particle will coalesce with the water layer on an adjacent particle to form concave menisci. The

vapor pressure at the surface of these menisci will be less than that existing at the surface of bulk water under the same pressure. Water will therefore transfer from bulk water to the porous solid mass until the menisci in the mass are all flat.

Thus water will transfer from bulk water to a dry porous solid until the pores are all filled, but the process will be initiated by one property of the system and completed by another. No differentiation is made between these two processes, and the difference of energy level which causes the transfer of water at any time is said to be the "suction" of the porous system for bulk water at that time.

These statements are true irrespective of the mechanism of water transfer.

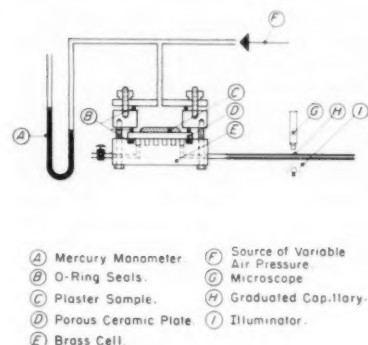


Fig. 1.—Suction apparatus.

## Apparatus

The apparatus for determining suction is shown schematically in Fig. 1. It consists of a brass and plastic cell into which is sealed, by means of O-rings, a 3-in. diam porous ceramic plate approximately  $\frac{1}{4}$ -in. thick. The ceramic plate was chosen so that the pores did not begin to empty of water below a pressure of 40 psi. The plate so chosen presented a high resistance to the flow of water through it, but this limitation had, of necessity, to be accepted. Beneath the ceramic plate is a small chamber consisting of interconnected annular grooves filled with water and connected to a capillary tube. Above the plate is a chamber connected to an air supply whose static pressure can be varied. The ceramic plate is saturated with water for the test. The plaster sample is placed on the ceramic plate. The meniscus in the capillary is observed through a microscope and movements corresponding to  $10^{-4}$  cu cm are readily detected.

## Test Results

After the plaster sample was placed on the ceramic plate, the cell was closed and

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

<sup>1</sup> The boldface numbers in parentheses refer to the list of references appended to this paper.

observations started. Water drained out of the plaster sample for some time. (Compare the account of water sorption test.) The relative impermeability of the ceramic plate precluded any rapid drainage even if this tended to occur. Drainage ceased and sorption of water by the plaster began. The pressure in the chamber above the plaster and ceramic plate was increased until the movement of the meniscus in the capillary ceased. With time the pressure necessary to prevent movement of the meniscus increased to a maximum (21.8 in. Hg with a probable error of  $\pm 2.0$  in. Hg) and then decreased to a value less than the maximum where it stayed more or less constant.

Figure 2 gives the results of twelve consecutive tests. Up to the point of maximum suction the plots represent the average of the times at which a chosen percentage of the maximum suction was attained. After the point of maximum suction, the plots represent the percentage of maximum suction obtained at chosen time intervals after maximum suction. Thus, up to maximum suction the probable error is one of time while after maximum suction the probable error is one of percentage suction. While all data used to obtain the curve shown were normally distributed, the data from one of the twelve curves deviated sufficiently from the remainder, after the point of maximum suction, for the data to be rejected after that point, and at 30 min after maximum suction time two of the remaining eleven curves gave data deviating widely enough to be rejected. The explanation for these anomalies is not known.

The method of least squares showed that suction began at 17.3 min and reached a maximum at 44.2 min.

#### Discussion of Results

In the earliest stage of the changing system being considered here, consisting of solid particles in contact with water, and in some cases with each other, by far the greater proportion of the solid surface available is so disposed as to represent the confining walls of pores, however ill-defined these pores may be. Withdrawal of water from this system results in a consolidating force acting on the particles of plaster. If consolidation cannot take place and the porous mass contains precisely that quantity of water needed to saturate it, then the menisci in the open mouths of the pores will depress and the free energy of the water in the mass will be lowered. Free water placed in contact with the porous mass will then be sucked into it.

If the particles provide little or no resistance to consolidation and do in fact consolidate, then the volume of the pore system is reduced, which tends to

maintain the initial curvature of the menisci and the initial energy level.

Since the pore system formed by the mixture of particles and water is non-rigid and capable of consolidation under gravity forces, it may be concluded that, as this consolidation takes place, an excess of free water can result. It is believed that this is what occurs in a 2:1 plaster-water mix. Water can therefore drain from the plaster, though slowly because of the relative impermeability of the ceramic plate. From the experimental data, suction is seen to begin at 17.3 min. However, before this time the excess mixing water, at least in part, is available to satisfy any demand for water by the plaster. Thus, almost certainly, a tendency to imbibe water (a state of "suction") is actually developed in the plaster before 17.3 min. When suction begins, and causes increased concavity of the meniscus in the observed reference capillary, pressure is applied to counteract it. The action of the pressure is to depress the menisci in the plaster and in the ceramic plate to provide water to satisfy the plaster's demand. The force necessary to do this is the same as the force with which water would tend to be imbibed by the plaster, under no-flow conditions, if the latter were placed in contact with free water. A curve of suction against

time is thus built up by observing the suction pressure at various times. It should be noted carefully that the test described measures the force necessary to depress menisci so as to supply water to satisfy a demand, but does not provide information concerning the reason for the existence of the demand, or its magnitude.

As previously stated, manifestation of suction by a tendency to imbibe water indicates that the plaster, is resisting consolidation.

The decay of suction from a maximum value is interesting. It might be explained either by a decrease in the total pore volume or by an increase in the average pore diameter.

A consideration of the absolute volumes of hemihydrate, dihydrate, and water shows that the hydration of hemihydrate to dihydrate produces a volume of the latter lower than the combined volumes of the hemihydrate and the water which formed it. However, the absolute volume of the dihydrate is about 40 per cent greater than the absolute volume of the hemihydrate from which it was formed. The density of the wet 2:1 plaster mix being considered here is 1.72 g per cu cm. For such a mix it may be calculated that the absolute solid-volume increase on hydration, expressed as a per cent of the total

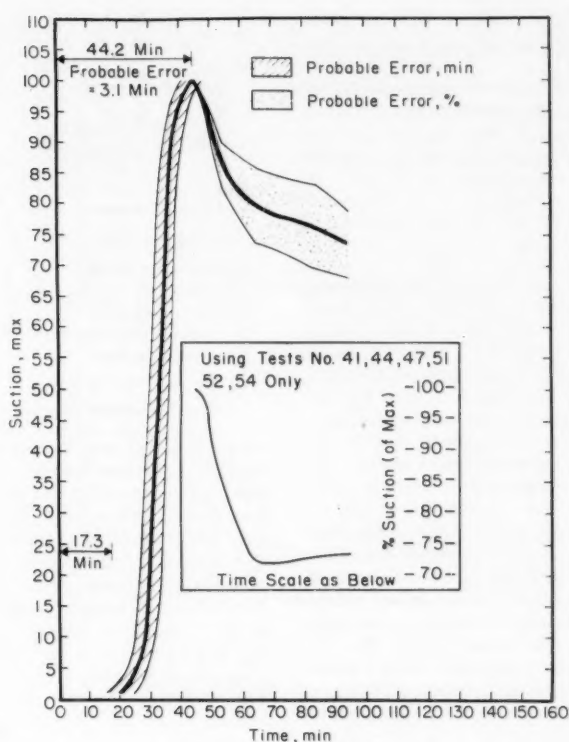


Fig. 2.—Development of suction.



volume of the mass, is 16.9 per cent.

$$100 \text{ cu cm mix} \equiv 172 \text{ g} \equiv 114.67 \text{ g CaSO}_4 \cdot \frac{1}{2} \text{H}_2\text{O}$$

$$114.67 \text{ g CaSO}_4 \cdot \frac{1}{2} \text{H}_2\text{O} = \text{absolute vol. of}$$

$$\frac{114.67 \text{ cu cm}}{2.75} = 41.70 \text{ cu cm}$$

Increase in volume on hydration of 41.70 cu cm of  $\text{CaSO}_4 \cdot \frac{1}{2} \text{H}_2\text{O}$

$$= 40.6 \times 41.70$$

$$\frac{100}{100}$$

$$= 16.93 \text{ cu cm}$$

If the apparent volume of the hydrating mass remained constant throughout the period of hydration it may readily be seen that the total pore volume of the mass would decrease from the start of hydration to accommodate the increased volume of the solid phase; the volume of water available to fill the pores would also decrease but at a rate somewhat higher than the rate of pore-volume decrease. However, as will be shown, the apparent volume of the mass at first decreases and then increases. The increase in apparent volume is of the order of 1 per cent. It is obvious that the 1 per cent apparent volume increase will have only a small effect in opposing the decrease in pore volume due to the growth of the solid phase. Thus to suppose that the drop in suction from a maximum is due to a decrease in the total pore volume necessitates the assumption that, at the time of the suction decrease, the decrease in pore volume normal to the hydration process is augmented by a mechanical consolidation of the solid material in the mass, as otherwise the relative rates of decrease of pore volume and free water respectively, will be undisturbed and will therefore increase the pore volume. Since the impossibility of such consolidation is believed to underlie the development of suction, this explanation for the suction decrease is not satisfactory.

The decay of suction from a maximum value is most readily explained by assuming an increase in the average pore diameter. This in turn could be explained by assuming the growth of large crystals at the expense of small, after the marked activity, which gives rise to the steep portion of the suction curve, has subsided. This suggestion is in line with the findings of Rebinder, *et al.* (10) and Bogautdinova, *et al.* (12) who found, within 1 hr of mixing, a decrease in strength after an initial maximum was reached. Rebinder, *et al.* (10), also refer to "disappearance of nonequilibrium crystal contacts" in connection with the mechanism of hardening of plaster.

#### Water Sorption

The technique adopted was to seal a disk of porous sintered bronze into a plastic dish, the bottom of which consisted of annular grooves. A sintered

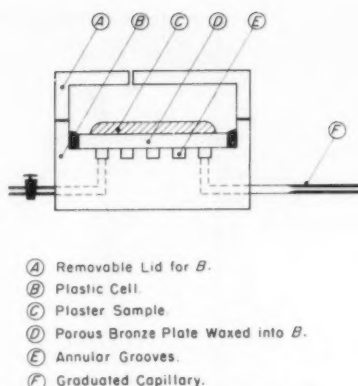


Fig. 3.—Water sorption cell.

bronze disk was used in place of a ceramic disk, because the sintered bronze was highly permeable and afforded the least possible resistance to flow of water into and out of the plaster sample. The grooves of the plastic dish were joined and then connected to a capillary tube fitted with a scale and having a capacity of 0.05 cu cm per cm. Two filter papers were placed on top of the bronze plate, the upper one being weighed dry. The plaster sample was placed on the filter papers. The apparatus is shown schematically in Fig. 3. To prevent flooding of the surface of the filter papers, the level of the capillary was placed about  $\frac{1}{2}$  in. below the upper surface of the bronze plate and so maintained the plate at a slight suction. This suction was considered negligible compared to

the suctions developed in the setting plaster. The plaster sample was from  $\frac{1}{8}$  to  $\frac{3}{16}$  in. thick. Mixing technique was the same as described under the section on Volume Change. The cell was vented through a 3-ft long capillary tube to diminish loss of water by evaporation. The timing of the steps necessary to start this test was reproduced from one test to another. Due to the operations necessary in starting the other two tests, observations of water sorption did not begin until 4 min, 25 sec.

#### Test Results

After the plaster sample was placed in the cell and the lid was closed, observations were started. Water drained rapidly from the sample, a period of inaction followed, and the plaster began to sorb water at about 7 to 8 min. The amount of water lost initially and the amount subsequently sorbed (overnight sorption = 100 per cent) is shown in Fig. 4.

Assuming that the plaster sets completely overnight, it was found that, on setting, the plaster sorbed 0.045 cu cm per g of dry set plaster with a probable error of 0.001 cu cm.

To check the reality of the period of inaction in water sorption mentioned above, three experiments were carried out in which the observations of water sorption were begun 50 sec after start of mixing. From these tests it was found that drainage proceeded as before, ceased at about 3 min and was followed

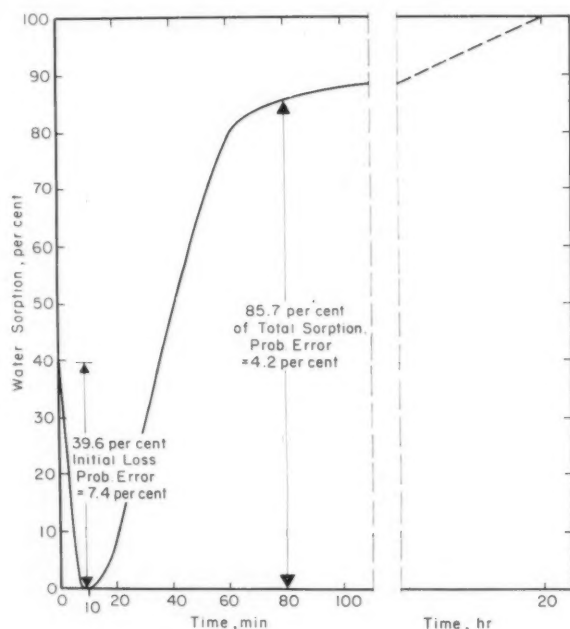


Fig. 4.—Water sorption.

by a period of apparent inaction lasting about 4 min after which sorption of water began. These results show that the period of "inaction" is not due simply to the particular experimental technique being used.

#### Discussion of Results

The phenomenon of initial drainage is believed to be due to the presence of water in excess of that necessary to saturate the hemihydrate present (see Suction Development). The period of apparent inaction is believed to be due to the compactable nature of the plaster mass at this stage of setting and the consequent possibility of supplying a demand for water by compaction of the mass, with release of free water. The compacting force is, of course, supplied by the surface tension of the water and/or gravity.

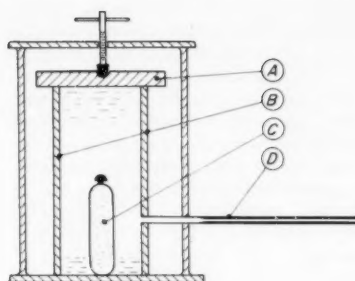
The sorption of water, following the period of apparent inaction, can be explained in large part by the demand for water caused by chemical hydration. The test provides no information as to whether this is the sole agency responsible. The mechanism causing the demand for water is believed to be operative before the water uptake begins and prior to this point to obtain necessary water by compaction of the plaster mass.

It is believed that the long duration of water uptake may be due partly to the impermeability of the set plaster mass to water under only moderate pressure differentials. Empty pores will be left in the plaster mass by chemical binding of water to form dihydrate. In regions of the mass remote from the source of free water, these pores will have to be filled by migration of water through the mass from the free water source. In this case the hydration proper will be largely complete in some time less than the period of water uptake. From the suction test data, 60 to 80 min does not seem unlikely.

#### Volume Change

The technique adopted for the present work was to fill a thin-walled rubber membrane with plaster, seal it securely, and place it in a brass tank filled with water and connected to a capillary tube (Fig. 5). A lid was then placed on the tank and readings started. The capillary tube was graduated and had a capacity of 0.05 cu cm per cm. Volume changes in the plaster registered as movement of the meniscus in the capillary.

Objections to the method are mainly that the tank and water in it expand under the influence of the heat released by the plaster hydration and consequently give a "thermometer-effect" error in the volume change. Pressure variations in the atmosphere will cause the



- (A) Removable Lid Clamped in Position
- (B) Brass Cylinder Filled with Water
- (C) Plaster in Membrane
- (D) Graduated Capillary

Fig. 5—Volume change apparatus.

apparatus to behave in some measure as a barometer. The latter objection is considered to be negligible and the former is thought to influence only the order of the volume change and not its position in time. In the initial stages of the hydration, indeed, when the temperature rise is very small, the thermometer effect is negligible.

#### Test Results

Due to the procedure involved in starting the water sorption and suction

tests, the first reading in the volume change test was usually not made before 5 min after the start of mixing. Invariably at this time, a rapid contraction was taking place. This contraction proceeded more or less uniformly for some time and then abruptly changed to an expansion. The expansion proceeded rapidly, gradually slowed to a stop, and was succeeded by a slow contraction. The shape of Fig. 6 is typical of the tests considered.

Consideration of fourteen consecutive tests (the data from which were found to follow closely a normal distribution pattern) showed the following:

- (a) Start of reading was, in all cases, 5 min.
- (b) Contraction proceeded until 25.6 min had elapsed (probable error was 4.4 min).
- (c) Expansion occurred for a subsequent period of 34.8 min (probable error was 2.2 min).
- (d) The percentage contraction was 0.25 per cent (probable error was 0.04 per cent).
- (e) The percentage expansion was 0.92 per cent (probable error was 0.03 per cent).

Since percentage contraction and contraction time showed normal distribution, the ratios of the duration of contraction to the percentage of contraction for the fourteen tests showed normal

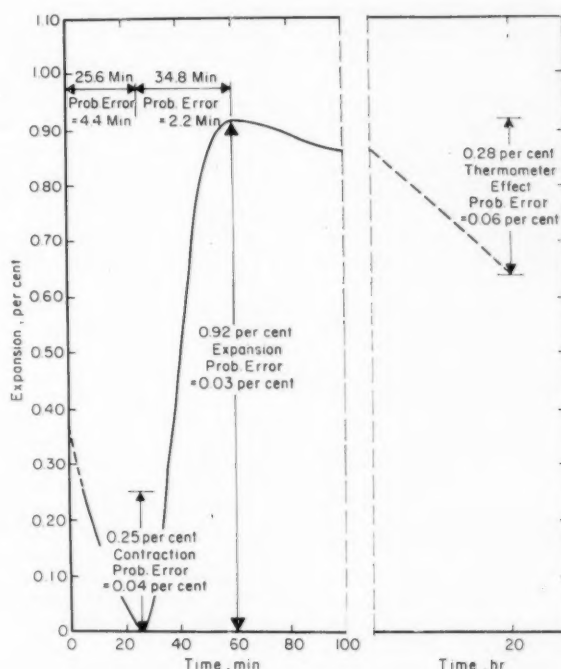


Fig. 6.—Volume change.

distribution. Arithmetic mean of the ratio was 102.4 with a probable error of 8.8. The method of least squares gave the relation:

$$c = 0.0074t + 0.061$$

where:

$c$  = per cent contraction and  
 $t$  = duration of contraction.

It is obvious that this relation does not hold to " $t_0$ " since at  $t = 0$ ,  $c = 0$ .

The comparative linearity of a typical time per contraction curve is of interest (Fig. 6) but should not be confused with the curve for which the equation has just been given. An attempt was made to determine temperature changes in the setting plaster and in the surrounding water but the reproducibility was poor due to the difficulty of positioning the thermocouples in the plaster mass. Such data as were obtained indicate an initial drop in temperature immediately after mixing, followed by a rise in temperature starting at about 14 min.

#### Discussion of Results

Otteaman (1) and Chassevent (5) have stated that the initial contraction is a manifestation of the decrease in absolute volume which occurs when hemihydrate and water react together to produce gypsum. This is believed to be the correct explanation. Apropos to Chassevent's comments quoted earlier, the present author is of the opinion that all results obtained in tests on plaster are comparative only and must always be related to the environment of the plaster mass being tested.

Average wet density of the plaster used in these experiments was 1.72 g per cu cm. Plaster to water ratio was 2:1. Average contraction was 0.25 per cent. Consideration of the molecular volumes of hemihydrate, gypsum, and water shows that a contraction of 0.25 per cent represents 5.6 per cent of the contraction to be expected on full hydration.

100 cu cm mix  $\equiv$  172 g  $\equiv$  114.67 g  $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$

145 g  $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O} = 5.59$  cu cm contraction in absolute volume on full hydration

$\therefore$  114.67 g  $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O} = 4.47$  cu cm contraction  
 $= 4.47$  per cent contraction

$\therefore$  0.25 per cent contraction =  
 $\frac{0.25 \times 100 \text{ per cent of full contraction}}{4.47}$

$= 5.6$  per cent

This indicates not only that hydration and its accompanying contraction in absolute volume is more than adequate to

explain the contraction found experimentally, but also that hydration of the hemihydrate begins at an early stage in the setting process.

Examination of the data available shows that the maximum contraction which could be accounted for by the decrease in temperature referred to above is approximately 0.05 per cent, and is probably considerably lower. The reason for the temperature drop is not clear unless it is due to the negative heat of solution of hemihydrate in water.

The conditions of the suction tests are such that drainage of free water out of the sample is virtually prevented, so that the conditions existing in the suction and volume tests may be compared directly. Since suction began at about 18 min., it follows that all free water in the volume tests was used up at this time or shortly afterwards. Since the first volume reading was taken at 5 min, the per cent contraction was linearly extrapolated to  $t_0$ . The average extrapolated contraction was 0.37 per cent (probable error of 0.05 per cent). Contraction ceased at 25.6 min (probable error of 4.4 min) and a contraction of 0.37 per cent represents 8.3 per cent of full hydration. Reference to the water sorption test (Fig. 4) gave the degree of hydration, at 25.6 min, as 18.9 per cent of total. Therefore  $18.9 - 8.3 = 10.6$  per cent of full hydration has occurred in the volume test sample without apparent manifestation as decrease in volume. This 10.6 per cent of hydration must, therefore, be represented by pores emptied of water within the volume sample. An absolute volume decrease of 0.47 per cent (of the absolute volume of the reactants) occurs for 10.6 per cent of the full hydration. Presumably, therefore, when the volume sample starts to expand, the mass contains pores empty of water to the extent of 0.47 per cent of the total volume of the sample.

Following the contraction, an expansion of 0.92 per cent (probable error of 0.03 per cent) occurs. No information regarding the mechanism causing the expansion is provided by the volume test, but see section on General Discussion.

Finally a contraction is observed following the expansion. This contraction is due to cooling of the plaster and apparatus after the exothermic hydration and provides a measure of the volume correction to be applied to the data to take account of the thermometer-like action of the apparatus in responding to the heat output of the setting plaster. The correction found is -0.28 per cent with probable error of 0.06 per cent.

Taking into account the decrease in absolute volume, together with the in-

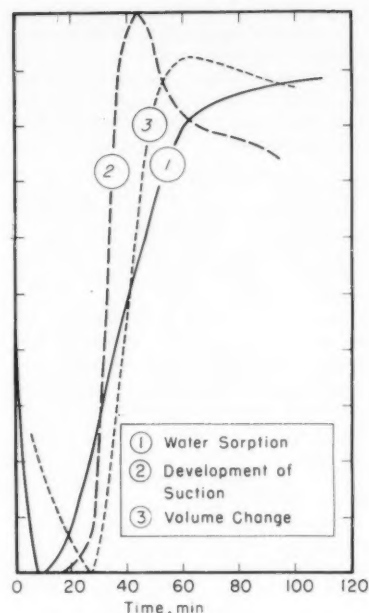


Fig. 7.—Composite curves.

crease in apparent volume corrected for temperature effects, it may be calculated that in a hardened wet 2:1 plaster mix there will be 6.4 cu cm of pores empty of water for each 172 g of gypsum produced.

The order of reproducibility given previously for the various measurements warrants attention. Reproducibility for the duration of contraction and for the percentage contraction is poor; it is somewhat better for the duration of the expansion, and good for the percentage expansion. These data are believed to shed some light on the well-known difficulty of obtaining a reproducible setting time with a neat plaster mix.

The fact that the ratios of duration of contraction to percentage of contraction are normally distributed is tentatively interpreted as showing that contraction occurs as a result of a reaction proceeding at a more or less uniform rate, and which continues until some limiting stage in the process is reached. It is believed that the limiting stage is the point at which compaction of the plaster mass can no longer readily occur and the variable factor is thought to be the amount of mixing water taken up when the sample for the test is removed from the main batch of plaster.

#### General Discussion

In this section an attempt will be made to correlate the data from the three tests one with another, and to attempt to establish the relation of these data with the relevant published literature. A composite showing the three superimposed curves is given in Fig. 7.



Assuming that plaster is completely set overnight, then, as stated before, the water sorbed is 0.045 cu cm per g of dry set plaster.

Again, expansion of the plaster from start of expansion (corrected for temp. effect) was 0.64 per cent. This may be compared with Chassevent's (5) expansion of a plaster not covered with water. Chassevent found a ratio of 1.37 for the expansion of a plaster covered with water to the expansion when not covered with water. Lehmann and Kreuter (2) found 1.40 for the ratio.

The plaster in the water sorption cell may be compared to Chassevent's plaster covered with water. Thus the expansion of the plaster in the sorption cell may be assumed to be  $1.37 \times 0.64$  per cent = 0.877 per cent.

Dry set density for plaster is 1.33 g per cu cm. (probable error very small).

∴ Expansion is 0.877 cu cm per 133 g of dry set plaster = 0.0065 cu cm per g of dry set plaster.

It may be shown readily from considerations of molecular volumes that the decrease in absolute volume associated with 1g of dry-set plaster (gypsum) is 0.033 cu cm.

For 1g the total increase in the volume of pores not filled with water for the plaster on setting is thus  $0.033 + 0.0065$  cu cm = 0.040 cu cm.

This is to be compared with the 0.045 cu cm per g found experimentally for water uptake.

It is believed that the assumptions made in assessing the porosity of the set plaster are legitimate, and it is concluded that the amount of water sorbed overnight is the full amount which will be taken up.

Where the initial set was determined with a Vicat needle (and due to a desire to save plaster the usual batch was too small for such a determination), it was found to occur at 20 min. At this time, water uptake was about 12 per cent of the overnight amount. Bogautdinova, *et al* (12), state that, at the initial set, 40 to 50 per cent of the water necessary to convert all the hemihydrate "to a dihydrate gel" was used. The difference in the two results may arise from different criteria for "initial" set and the permeability factor previously discussed.

It is of interest at this point to consider suggestions to account for the volume contraction other than the one discussed above. Williams and Westendick (4) suggest that the contraction is due to dissolving of the hemihydrate in the mixing water, while Neville (9) suggests a process of adsorption onto the hemihydrate as causing the contraction. Fisher (8) postulates that up to about 30 min after mixing only a process of adsorption occurs, a gradual change to

chemisorption taking place after this time. Thus by implication he agrees with Neville. Powell (11) on the other hand has published contrary data.

Simple calculation shows that the volume of hemihydrate dissolved in the mixing water is inadequate to explain the contraction found, and there is little evidence to show any marked decrease in the volume of the water molecule on entering the adsorbed state. The postulations regarding adsorption as a mechanism leading to initial set, Fisher's (8) concept (involving adsorption) of the mode of action of retarders, and the concept of Rebinder, *et al*. (10), of the plaster, up to a time of 5 min after mixing, as a coagulated mass of low shearing strength, may be reconciled with the data which suggest a purely crystallizational hardening, by supposing that adsorption takes place, but only in the first few minutes of the plaster's setting time. Penetration of fine pores by an adsorption process occurs until the water makes contact with gypsum nuclei whose presence is a virtual certainty, and from these centers crystallization spreads throughout the mass. The limiting factors which determine the induction period of the set are the number of gypsum nuclei present and the fineness of the plaster grains. Support for this suggestion is furnished by the findings of Neville (9) that a crystalline hemihydrate, prepared by boiling gypsum shows anomalous setting properties, by the findings of Murray (private communication) that a perfectly pure hemihydrate will not set, and by the findings of Emley and Welch (13) that the finer the plaster the quicker the set.

### Conclusion

Hydration of the hemihydrate plaster mix considered here begins virtually at once after mixing with water. Until about 17 min demands for water occasioned by hydration are met by compaction of the plaster mass under the influence of surface tension and/or gravity. At the same time a rigid structure is rapidly developing in the mass due to microcrystallization, interlocking of crystals, and trapping of hemihydrate particles. Increase in volume of pores empty of water has started by now. Compaction becomes more difficult to achieve by surface tension from 17 to 26 min, and by 26 min it has virtually ceased. Increase of the apparent volume now begins.

The reason for the increase in apparent volume is as follows: Needle-like crystals do not pack well. The gypsum formed on hydration is in the form of needles. Consequently the increase in the absolute volume of the solid phase is not manifested by the

growth of gypsum crystals into the pores of the setting plaster, to produce a mass of increasing density; instead, crystals of gypsum grow until they make contact with other growing crystals. Increase in the number of such crystal contacts, together with continual growth of the solid phase, produce a skeletal structure of ever-increasing strength, the individual structural members of which continue to increase in size. Such increase in size of structural members causes the increase in the apparent volume of the setting mass. By 44 min equilibrium is established between the demand for water occasioned by hydration and supply of water by depression of menisci. However, immediately after establishment of this equilibrium, growth of large crystals at the expense of small and disappearance of "non-equilibrated crystal contacts" (10) increases the average pore size and decreases suction. Cessation of the bulk of these crystal changes allows suction once more to reach equilibrium. Further slow hydration causes suction to rise once more to a level higher than the lower equilibrium level.

### Acknowledgment

This paper is a contribution from the Division of Building Research, National Research Council of Canada and is published with the approval of the Director of the Division.

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## The Significance of Iron in Asbestos Materials Used for Electrical Insulating Purposes

By P. O. NICODEMUS

**P**RACTICALLY all existing specifications for asbestos materials used for electrical insulation have requirements for the maximum amount of total iron and/or magnetic iron they may contain. Terms such as "magnetic iron content," "magnetic rating," and "total iron content" have been used for years in such a loose and confused manner that much misunderstanding has resulted regarding these terms. This is particularly true among people working in the electrical field not familiar with the sciences of chemistry and mineralogy.

Since 1951, Subcommittee A-4 on Asbestos and Its Textile Products of ASTM Committee D-13 on Textile Materials has been studying the significance of these requirements. A considerable amount of work has been carried out by various government, industrial and institutional laboratories represented on the subcommittee in an effort to reach some logical conclusions concerning these requirements and to make recommendations to those in the electrical insulating field responsible for writing specifications for asbestos materials used for electrical purposes.

This paper is a report of the work done, the conclusions reached, and the recommendations of the subcommittee.

### Types of Asbestos

First, a study was made of the various types of asbestiform fibers which may be used in materials used for electrical insulation and the manner in which iron exists in these fibers.

There are about thirty minerals of fibrous crystalline structure comprising the asbestiform group. They are usually hydrated metallic silicates which vary widely in chemical composition but have one thing in common, their fibrous form. The so-called fibers are actually crystals which have extremely small diameters in relation to their length. Thus, they exhibit many of the properties of regular organic fibers. The four most important are chrysotile, crocidolite, Amosite,<sup>1</sup> and anthophyllite. The first of these, and most important, is a form of serpentine; the other three are amphiboles.

While any mineral may be given a general chemical formula, nature is by no means constant, and it is seldom that a so-called "pure" mineral, with an exact chemical formula, exists. Mineral "impurities" may exist as a replacement for an element in the molecular structure or as an "inclusion," in the form of a metal or metallic oxide, around the molecules.

An example of the former would be the replacement of some of the atoms of magnesium by iron atoms in a crystal of magnesium silicate. A familiar example of inclusions would be inclusions in a crystal of silicon dioxide which, when pure, exists as transparent crystals known as quartz. When colored by inclusions of iron and manganese, it is called amethyst. Cryptocrystalline forms colored brown or red by iron oxide inclusions are known as agate, jasper, or onyx.

This is true too for the asbestiform minerals. While definite chemical formulas have been assigned to them, they seldom exist in the pure form. The "impurities" may greatly affect the physical and electrical properties of the asbestos, as well as the chemical composition. In Table I is given an average chemical composition of the four most important asbestiform minerals.

Table I gives the average composition of these fibers, but tells us nothing of the way nature has combined these various oxides to form the fiberlike crystals. By various types of crystallographic an-

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<sup>1</sup> Trade name for a monoclinic amphibole mined in Transvaal (S. Africa) by the Asbestos Mine of South Africa (AMOS).

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TABLE I.—AVERAGE CHEMICAL COMPOSITION, PER CENT.

	Chrysotile	Crocidolite	Amosite	Anthophyllite
SiO <sub>2</sub> ...	39.0	56.0	47.0	57.0
Al <sub>2</sub> O <sub>3</sub> ...	0.5	0.5	4.0	1.0
Fe <sub>2</sub> O <sub>3</sub> ...	3.0	16.0	3.0	...
FeO...	2.0	12.0	37.0	8.0
CaO...	0.5	1.0	0.5	...
MgO...	41.0	9.0	6.0	31.0
H <sub>2</sub> O...	13.5	2.0	2.0	3.0
Cr <sub>2</sub> O <sub>3</sub> ...	...	...	...	...
CO <sub>2</sub> ...	0.5	...	...	...
Na <sub>2</sub> O...	...	3.0	Trace	...
K <sub>2</sub> O...	...	0.5	Trace	...

alyses, including X-ray diffraction, differential thermal analysis, and electron microscope observations, the manner in which these various elements are combined in the crystals has been established as follows:

*Chrysotile* is a basic hydrated magnesium silicate, the chemical formula for which can be expressed in various ways—the simplest being  $3\text{MgO} \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$ . The water of crystallization in different varieties of chrysotile varies somewhat, with the average being about 14 per cent. In some cases iron may replace a small portion of the magnesium in the molecule, also small amounts of aluminum, calcium and manganese have been found in the crystals. The individual crystals of chrysotile are extremely small in diameter—about  $10^{-6}$  in.—and vary in length from a fraction of an inch up to 2 in. When we speak of opened chrysotile fibers, we are actually speaking of bundles of these extremely small fibrils. Closely associated with these fibrils and fibers are still other impurities—inclusions of the various oxides of iron, including magnetite—the one with which we are most concerned. In some cases, these oxides occur on the ends of the fibrils and can be removed; in other cases they permeate the bundles and surround the extremely narrow fibrils in such a manner that it is impossible to remove them.

The chrysotile fibers are strong, soft and pliable. Because of these properties, it is the most important form of asbestos for textile and electrical use.

*Crocidolite* is a complex silicate of iron and sodium with a probable composition represented by the formula  $\text{NaFe}(\text{SiO}_3)_2 \cdot \text{FeSiO}_3 \cdot \text{H}_2\text{O}$ . This material is known as blue asbestos, the color being imparted by the ferrous oxide in the crystals. While iron is included in the molecular structure itself, there is little or no iron oxide associated with it as inclusions. The fibers of this material are harsher than those of chrysotile and more difficult to process, but some is employed for textile and electrical use.

*Amosite*<sup>1</sup> is essentially a silicate of iron and magnesium, which may be expressed by the formula  $(\text{FeMg}) \text{SiO}_3 \cdot 1$  to 5 per cent  $\text{H}_2\text{O}$ . The fibers are

quite long and flexible, but very harsh, and little is used for textile or electrical purposes. Its principal use is for thermal insulation.

*Anthophyllite* is a complex iron, magnesium silicate of variable composition. One variety may be expressed by the formula  $(\text{Fe, Mg})_7 \text{Si}_8 \text{O}_{22} (\text{OH})_2$ . Some of the iron may be replaced by magnesium, or some of the magnesium may be replaced by iron. The fibers are, in general, very brittle; however, recently a source with a high magnesium content has been discovered which is said to have relatively soft fibers which can be employed for textile and electrical use. The amount of this material is very limited and of little importance at present.

#### Total Iron

It should be noted that iron appears in the written molecular formula of fiberlike crystals of the three amphiboles, but not in the one serpentine—chrysotile—although, as stated above, an analysis of this material may show up to 6 per cent total iron. This is present primarily as inclusions around the fibrils, but a small amount may be present as an isomorphous substituent in the crystal structure or as a replacement for a small portion of the magnesium in the crystal lattice.

#### Magnetic Iron

We have seen that associated with chrysotile fibers are the oxides of iron, which as inclusions may be loosely stuck to the fibril bundles or may surround the fibrils in such a manner that they may be considered part of the fiber. In the former case, a considerable portion of the oxides is removed in processing the fibers; in the latter case, it is impossible to remove them and maintain any reasonable fiber length. These oxides certainly do not impart any desirable characteristics to the fiber; but on the other hand, from an electrical insulating standpoint, it is only the magnetic oxide or magnetite which is an electrical conductor, and therefore definitely harmful. The other oxides of iron are not conductive and may actually be considered as electrical insulators.

The chemical formula for magnetite is usually written  $\text{Fe}_3\text{O}_4$ . A more realistic

formula would be  $\text{FeO} \cdot \text{Fe}_2\text{O}_3$ , as magnetite contains a molecule of the divalent ferrous oxide and a molecule of trivalent ferric oxide in a resonating system.

This mineral may exist with chrysotile in a variety of forms ranging in size from microscopic particles, up to pseudomorphs 0.25 in. or longer in length, and attached to the crystal with varying degrees of tenacity. For an evaluation of the electrical properties of the material, it is necessary not only to determine the amount of magnetite present but also, if possible, the size of the magnetite particles. The microscopic particles have little significance for they cannot conduct a current further than their own diameter and therefore, would decrease the dielectric strength but little. Large particles, on the other hand, could conceivably extend through the total thickness of insulation causing a conducting path.

#### Total Iron, Magnetic Iron, and Electrical Properties

Because it is superior to other types of asbestos for textile processing as well as for industrial purposes generally, chrysotile accounts for about 95 per cent of the total amount of natural mineral fibers used. It is incidental that it also contains the least amount of total iron and the largest amount of magnetic iron.

Until recently it was believed that the electrical properties of asbestos materials were directly related to: (a) the total amount of iron present, and (b) the amount of magnetic iron present. It is for this reason that specifications for asbestos materials used for electrical purposes place a maximum on the amount of total iron and magnetic iron which may be present.

As magnetite is an electrical conductor it is obvious that the amount of this material in asbestos materials used for electrical insulating purposes is directly related to the electrical properties of the material and must be kept to a minimum.

The role of the total iron present, however, appears to be rather obscure, for the other oxides of iron which may be present in the asbestos fiber inclusions are nonconductive and any iron present in the molecular structure of the asbestos crystals should not affect the electrical properties of the fibers any more than the other metallic elements present.

#### Electrical Properties of Asbestos Fibers

In order to study the dielectric properties of these four types of asbestos, felts, or mats, of the fibers all approximately 0.035 in. thick were prepared. Their thickness was accurately measured by a dead-weight micrometer (ASTM





Fig. 1.—Radiograph of fourteen samples tested showing amount of magnetite present and particle size.

Methods D 374-75 T method C),<sup>2</sup> and the dielectric strength in volts per mil measured (ASTM Methods D 202-55 T).<sup>3</sup> Three specimens of chrysotile, two specimens of anthophyllite, and one each of crocidolite and Amosite were tested in this manner. The average volts per mil and the total iron content of these specimens are given in Table II.

From this table we can see that the

<sup>2</sup> Tentative Methods of Test for Thickness of Solid Electrical Insulation (D 374-57 T), 1958 Book of ASTM Standards, Parts 6, 9 and 10.

<sup>3</sup> Tentative Methods of Sampling and Testing Untreated Paper Used for Electrical Insulation (D 202-55 T), 1958 Book of ASTM Standards, Parts 6 and 9.

<sup>4</sup> Method of Test for Magnetic Rating of Asbestos Used for Electrical Purposes (D 1118-57), 1958 Book of ASTM Standards, Parts 9 and 10.

<sup>5</sup> Portions of Fellowship Reports by M. C. Shaw, Research Fellow, Asbestos Textile Inst., which were presented to Subcommittee A-4 of ASTM Committee D-13 and are carried as part of their Minutes.

TABLE II.

Material	Average Total Iron, per cent	Average Thickness, in.	Dielectric Strength, v per mil, average
Chrysotile....	6	0.0390	95
Amosite.....	40	0.0339	110
Anthophyllite	15	0.0345	127
Crocidolite...	35	0.0368	93

felts of fibers containing high percentages of total iron were equal or superior to the chrysotile felts in dielectric strength.

Next, fourteen samples, representing various varieties of asbestos fiber were taken for study. These included ten samples of five varieties of Canadian chrysotile, two of African chrysotile, one Arizona chrysotile, and one Amosite.

These were analyzed for total iron content, magnetic iron content (magne-

tic rating per ASTM Method D 1118-57<sup>4</sup>—described later) and radiographic analysis.

The various samples, their source, grade, total iron content and magnetic rating are given in Table III.<sup>5</sup>

If the above fibers were classified for suitability for electrical insulating purposes on the basis of being chrysotile and for a maximum of 4 per cent total iron (according to some present specifications), only Nos. 11 and 13 could not be used. By ASTM standards, the magnetic rating requirements would exclude Nos. 4, 6, 10, 11 and 12.

The reason these latter samples should be eliminated, as well as the differences in all fourteen samples, which the total iron determination cannot show, can be visually observed in the reproduction of the radiograph (Fig. 1).<sup>5</sup> The specimens, each exactly 10.00 g of fiber, were

TABLE III.

Sample	Source	Grade	Total Iron	Magnetic Rating
No. 1, chrysotile....	Canada	1	1.01	Trace
No. 2, chrysotile....	Canada	4K	1.79	0.75
No. 3, chrysotile....	Canada	3K	1.82	0.90
No. 4, chrysotile....	Canada	F-150	4.00	5.55
No. 5, chrysotile....	Canada	3R	2.88	2.90
No. 6, chrysotile....	Canada	1	2.95	5.25
No. 7, chrysotile....	Africa	2	1.75	1.10
No. 8, chrysotile....	Canada	3R	1.55	1.65
No. 9, chrysotile....	Canada	3K	2.88	2.65
No. 10, chrysotile....	Canada	2	5.55	3.50
No. 11, chrysotile....	Canada	3R	3.21	8.30+
No. 12, chrysotile....	Canada	3R	3.21	4.40
No. 13, Amosite....	South Africa	1	30.05	0
No. 14, chrysotile....	Arizona	1	0.52	Trace

prepared by mixing the fibers with water into a slurry, after which the mass was dried by filtering on a filter paper, compressing under slight pressure, then air dried for 48 hr. The size and shape of all specimens were kept the same in order that a direct comparison could be made. In this reproduction the magnetic iron shows up as very light colored specks. This technique provides a visual method of determining not only the amount of magnetite present, but also the size of the magnetite particles.

If these samples were listed in the order of the number of magnetite particles that can be seen, they would appear in the order given in Table IV.

Thus we can see that the amount of magnetic iron as seen visually agrees almost perfectly with the magnetic rating of the various samples, while there is only a rough correlation with the amount of total iron present. It can be further observed that there is no correlation between magnetic iron and total iron, for in some samples the magnetic rating is half the value of total iron content; in others it is approximately equal to the per cent of total iron; and in still others it is as much as one-and-a-half times the percentage of the total iron present.

Efforts were made to determine the volume resistivity of the various fibers, but no satisfactory method could be devised. With the method used, there was more variation between the individual samples of a given fiber than between the various types of fiber. This was also true of various molded asbestos-plastic compositions.

#### Significance of Total Iron

Based on this and other unreported work, the subcommittee came to the conclusion that:

"There is no correlation in the total iron content of asbestos fibers or materials made from them as related to any of the electrical properties which are important in the use of asbestos in electrical insulation."

<sup>6</sup> International Critical Tables, McGraw-Hill Publishing Co., Inc., New York, N. Y., Vol. VI, p. 413 (1929).

#### "Navy Method" for Determining Magnetic Iron

There are presently two methods generally used for determining the amount of magnetic iron in asbestos used for electrical purposes. The first is the so-called "Navy Method" which is now part of Military Specification (MIL-I-3053A) for Insulations, Electrical, Asbestos Fiber, Treated and Untreated. According to this method the asbestos sample is placed in a crucible and heated for 1 hr at  $845 \pm 30$  C, cooled and reduced to a fine powder. This powder is suspended in hot water and any magnetite removed by means of an electromagnet. The magnetite thus removed is dried, weighed, and the per cent of magnetite, based on the original sample, calculated.

**Variable Results of "Navy Method."**—Results obtained by this method are extremely variable and depend on the equipment and technique used. In the author's laboratory two trained technicians, using the same equipment and duplicates of a composite sample prepared from a ferrous grade A asbestos lap, showed an 18 per cent error between duplicate samples of one operator, and a 55 per cent error between the average results of the two technicians.

#### Specific Magnetism versus Temperature of Magnetite

Let us look at some possible explanations for this serious error. In Table V is given the specific magnetism versus temperature taken from the section covering the properties of magnetite of the International Critical Tables.<sup>6</sup>

From the table we see that magnetite heated to 216 C retains only 81 per cent of its maximum specific magnetism; at 540 C only a third is retained; and at 578.3 C the magnetite is completely oxidized to ferric oxide (provided there is sufficient oxygen present). We could actually say that heating in air would be a good method for reducing the magnetite in asbestos rather than being a method for determining it.

To demonstrate this property 1,000-g samples of National Bureau of Stand-

TABLE IV.

Sample	Visible Magnetite Particles	Magnetic Rating	Total Iron
No. 1....	None	Trace	1.01
No. 13....	None	0	30.05
No. 14....	None	Trace	0.52
No. 2....	Few	0.75	1.79
No. 3....	Few	0.90	1.82
No. 7....	Few	1.10	1.75
No. 8....	Few	1.65	1.55
No. 9....	Moderate	2.65	2.88
No. 5....	Moderate	2.90	2.88
No. 10....	Numerous	3.50	2.66
No. 12....	Numerous	4.40	3.21
No. 4....	Numerous	5.55	4.00
No. 6....	Numerous	5.25	2.95
No. 11....	Numerous	8.30+	5.55

TABLE V.—SPECIFIC MAGNETISM VERSUS TEMPERATURE.

Temperature, deg Cent	Specific Magnetism, per cent
-253.....	98.6
+17.3.....	93.2
116.4.....	88.0
216.0.....	81.0
315.5.....	72.2
409.0.....	61.3
497.0.....	45.7
539.5.....	33.4
556.6.....	25.9
568.0.....	18.3
573.0.....	13.3
578.3.....	Curie point <sup>a</sup>

<sup>a</sup> The Curie point is the temperature at which a ferromagnetic substance becomes paramagnetic.

ards standard magnetite 29a were heated for 1 hr in air at various temperatures, cooled and mixed with enough inert zinc oxide to fill the sample holder of the ASTM instrument for determining the magnetic rating of asbestos (ASTM D 1118-57).<sup>4</sup> This method is discussed below.

Table VI<sup>5</sup> shows the data for the magnetic rating of the samples heated to various temperatures. We can see that there is a very appreciable difference in the electromagnet effect of the sample after heating.

TABLE VI.

Temperature		Magnetic Rating
deg Fahr	deg Cent	
Room	Room.....	7.8
500	260.....	7.8
800	427.....	4.2
1200	649.....	0.1

It is quite probable that the "Navy Method" was written without considering some of these properties. This variation in magnetic rating with heating at various temperatures explains the variable results obtained by the "Navy Method" and the serious errors usually encountered with different equipment and technique.

#### ASTM Method for Determining Magnetite

The second method commonly used for determining magnetic iron in asbes-

tos for electrical insulating purposes is the above-mentioned ASTM method.<sup>4</sup> In this method the magnetite is determined by a magnetic analyzer and expressed empirically as the magnetic rating, MR, of the asbestos. The method is based on the principle of comparing the electromagnetic effect of an unknown sample of asbestos with the electromagnetic effect of a known standard. The analyzer is calibrated by means of a standard magnetic sample uniformly distributed throughout enough inert material, such as zinc oxide, to fill the sample holder, which is of specified dimensions. As we shall see, this method has some shortcomings, but it does give fairly reproducible results, not only with a given instrument, but with different instruments in different laboratories.

#### Factors Influencing Results

The magnetic rating of an asbestos sample, as measured in the above manner, is unfortunately, a function not only of the amount of magnetite present, but also of the size and orientation of the particles in the sample holder.

#### Particle Size

We have seen that in chrysotile asbestos the magnetite particles can vary from microscopic particles to needle-like pseudofibers 0.25 in. or more in length—yet relatively small in the other two dimensions. It is natural to expect the larger pieces to change the magnetic flux of the indicating instrument more than would an equal weight of well-distributed microscopic particles.

In order to prove this, a sample of standard magnetite was separated by screens into four fractions. Exactly 0.5 g of each fraction was thoroughly mixed with enough inert zinc oxide to fill the sample holder, the amount being constant for all samples. The magnetic ratings of these four fractions are given in Table VII.<sup>5</sup>

TABLE VII.

Fraction	Magnetic Rating
On a No. 35 sieve .....	4.40
Through a No. 35, on a No. 80-sieve .....	3.70
Through a No. 80, on a No. 200 sieve .....	3.50
Through a No. 200 sieve .....	3.05
Composite sample .....	3.90

This shows conclusively that grain size affects the magnetic rating of chrysotile asbestos as determined by this method.

#### Orientation

When the magnetic particles are present in the form of needlelike prisms,

<sup>5</sup> Specification and Methods of Test for Asbestos Tape for Electrical Purposes (D 315-52), 1958 Book of ASTM Standards, Part 9.

they show directional properties with regard to magnetic permeability, with maximum forces being exerted parallel to the longer dimension of the particle.

This property was demonstrated by placing a sample of woven asbestos cloth in the specimen holder with (a) the warp parallel to the long dimension of the holder, (b) the fill parallel to the long dimension of the holder, and (c) the cloth diagonally in the holder. The cloth was then unravelled and the yarn placed in the holder first parallel, then perpendicular to the long dimension. The magnetic rating of these various specimens are given in Table VIII.<sup>6</sup>

TABLE VIII.—MAGNETIC RATING.

	Warp Parallel	Fill Parallel	Diagonal
Cloth...	2.95	1.80	2.40
	Parallel	Perpendicular	
Yarn...	3.1	1.75	...

In each case, the maximum MR was obtained when the greatest number of particles were parallel to the magnetic field. Also, the yarn MR was higher than that of the cloth when parallel to the field, and lower than that of the cloth when perpendicular to the field. The average MR for both the cloth and the yarn when parallel and perpendicular is almost identical to the MR obtained when the cloth was placed diagonally in the holder.

As this example demonstrated this phenomenon very clearly, the subcommittee has inserted in the ASTM Method D 1118 the following note:

"The procedure here described is applicable only under those conditions wherein the magnetic particle distribution is such as to give the ultimate in random orientation. The magnetic particles in chrysotile asbestos, however, are most frequently needle-like or pseudofibrous, and as such exhibit directional properties with regard to magnetic permeability. Therefore, there must be an understanding as to the extent of the fibrous characteristics and the grain size distribution of the magnetic particles present in the sample if a proper evaluation of the resulting magnetic rating is to be factual. In view of the fibrous characteristics of the magnetic particles, the method of sample preparation and the placement of the sample in the sample holder must be carefully pursued in an endeavor to obtain a test specimen that will exhibit a maximum in random orientation."

#### Other Methods

For certain asbestos textile products such as woven tape and cloth, nonwoven sheet and tapes (asbestos papers), there is a very reliable method of determining the number of large particles of magnetite present per unit area of material.

This method is described under ASTM Specification and Methods of Test for Asbestos Tape for Electrical Purposes (D 315-52).<sup>7</sup> Briefly, this method consists of running the material between clean copper rollers which are connected in series with a 110-v, 25-w incandescent lamp, to a 110-v, 60-cycle circuit. The number of flashes or glows of the lamp indicates the number of magnetite particles large enough and so oriented as to be conductive. Naturally, the thinner the material, the smaller will be the particles of magnetite the method will detect.

Another interesting method of determining the magnetite present in asbestos was studied by the subcommittee. As we have seen, magnetite is composed of a molecule of divalent ferrous oxide and a molecule of trivalent ferric oxide. As the divalent oxide rarely, if ever, exists naturally, it is reasonable to believe that in an analysis of chrysotile asbestos, with the exception of the small amount of ferrous iron which may exist in the crystal lattice, any divalent oxide present would exist as a portion of the magnetite present. Theoretically, if there were no ferrous oxide present, there would be no magnetite present. If 1 per cent of ferrous oxide were found, we would expect slightly more than three times—or 3.22 per cent—of magnetite to be present.

While this is theoretically true, the trick is to prepare the sample for analysis without oxidizing any of the ferrous oxide. It has been estimated that as much as 30 per cent of the ferrous iron originally present would be oxidized in grinding the sample for analysis. For this reason, the method was abandoned as it is believed that as a control method it is too inoperative and too expensive for the value obtained. The ASTM Method D 1118-57<sup>4</sup> is believed more reliable, and certainly a simpler method for control work.

#### Significance of Magnetic Iron

Based on the above evidence, the subcommittee has come to the following conclusions regarding magnetic iron in asbestos materials for electrical insulating use.

1. There is a correlation between (a) the amount of magnetic iron or magnetite and (b) the size of the magnetite particles occurring in asbestos fibers and materials made from them as related to any electrical property.

2. ASTM Method D 1118-57<sup>4</sup> is adequate and is sufficiently accurate a method for determining relative magnetic iron content of asbestos materials, providing all relevant conditions as appended to the written specifications are taken into full consideration.



## Recommendations

In view of the above work, Subcommittee A-4 of ASTM Committee D-13 therefore recommends that industry and Government specifications for asbestos materials used for electrical in-

ulating purposes be critically reviewed; that the total iron requirements be deleted, since they are meaningless; and that requirements for the maximum amount of magnetic iron only, as determined by ASTM Method D 1118-57, be considered in these specifications.

## DISCUSSION

Mr. N. W. EDGERTON.<sup>1</sup>—The author is to be congratulated for throwing much needed light on an important and frequently misunderstood problem. It is to be hoped that he will succeed in laying the ghost of total iron.

As a matter of fact we would go even further and suggest that even magnetic rating is of limited usefulness. The author points out and we agree that it is the large particles which cause the trouble in electrical applications.

When the magnetic rating test yields a very low result we can infer that there are few large particles because there is very little magnetite of any size. If we are not so fortunate as to find a low magnetic rating, which is usually the

case when dealing with the more common fibers, the question arises whether the presence of large particles is reliably indicated by the magnetic rating.

In our laboratory we have obtained a large body of data, mostly on milled fibers for papers and textiles, which indicate that there is little, if any, correlation between magnetic rating and the electrical properties of dielectric strength, burnout rating or conducting particle count, volume resistivity, dielectric constant or power factor. This lack of correlation, especially with dielectric strength and burnout rating, which are more sensitive to local irregularities, exists because there are so many small particles that the presence of a few large ones has no discernible effect on the magnetic rating.

It is hoped that this paper will be helpful in bringing some order to a subject which has been in a state of confusion for many years and that specifications for asbestos used for electrical purposes will now be written with meaningful electrical requirements.

In view of this finding we look on magnetic rating as only a small part of the solution to the problem. What is really needed is a reasonably convenient method of obtaining the distribution of sizes of the conducting particles in the material.

Mr. P. O. NICODEMUS. (author)—The subcommittee could not agree with Mr. Edgerton's statement that "there is little, if any, correlation between magnetic rating and the electrical properties of dielectric strength, burnout rating or conducting particle count." As far as the electrical properties of volume resistivity, dielectric constant, or power factor are concerned—we do not know—for we have not found what we consider a suitable reproducible method of measuring these properties on asbestos fibers."

<sup>1</sup> Johns-Manville Research Center, Manville, N. J.

# High Precision Nondestructive Thickness Measurements of Organic Coatings

BY E. P. BRIGHTWELL

FUNDAMENTAL research on properties and behavior of organic coatings frequently involves thickness or changes in thickness as one of the important parameters. Such research also frequently requires that sequential thickness measurements be made on a given spot through the course of an experiment. Nondestructive methods based upon electromagnetic induction instruments have long been available, but these are limited to magnetic substrates and often lack the needed precision. An accurate but semidestructive optical method (1)<sup>1</sup> is also available for measuring film thickness. Nondestructive measurements of very thin clear films have also been made by using interference phenomena that occur when a thin film is exposed to visible

light (2). However, the use of visible light restricts the method to very thin (<0.1 mil) clear films.

In the present paper a method based upon infrared interferometry is described. The method has an average standard deviation of 0.008 mils for coatings 0.1 to 3 mils thick. It is applicable to pigmented coatings attached to any reasonably smooth metal substrate and to clear films over silicon or graphite. It is rapid, nondestructive and can be carried out with any infrared spectrometer that is equipped for reflectance measurements.

## Theory

The theory and technique for measuring the thickness of very thin clear films using interference phenomena of transmitted or reflected visible light is

well known (3). The infrared radiation technique can be used on relatively thick clear or pigmented films, because of the relatively long wavelength in the infrared region and because most pigmented materials are at least partially transparent to infrared radiation. For this technique to be successful, a minimum of about 20 per cent of the incident radiation must be transmitted. Some films do not meet these requirements. The controlling factors are: kind and amount of pigment and film thickness.

A complete explanation of the theory is given in Appendices I and II. However, a casual inspection of Fig. 1 will reveal its essential points. The incident beam *I* strikes the surface at an angle  $\theta$  and is divided into two beams. Beam *I* is reflected from the top surface. The remainder of beam *I* penetrates the film, is refracted and then reflected from the substrate, and finally

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

<sup>1</sup> The boldface numbers in parentheses refer to the list of references appended to this paper.

E. P. BRIGHTWELL has been associated with the Research Division of the Fabrics and Finishes Department of E. I. du Pont de Nemours and Co., Inc., Wilmington, Del., since 1951 where he has been engaged in developing testing instruments and techniques for measuring physical properties of polymeric materials.



emerges from the film as beam 2. The phase difference at points *f* and *e* determines whether constructive or destructive interference will occur.

For constructive interference to occur it can be shown (Appendix I) that film thickness, *t*, and wavelength,  $\lambda$  are related as follows,

$$t = \frac{m \lambda}{2n \cos \theta_1} \dots \dots \dots (1)$$

where *n* is the index of refraction and *m* = 0, 1, 2, 3, . . .

And to produce destructive interference

$$t = \left( \frac{2m + 1}{4n \cos \theta_1} \right) \lambda \dots \dots \dots (2)$$

In general the value assigned to *n* cos  $\theta_1$  is only an approximation since values of the index of refraction in the infrared region are usually not available and vary with wavelength. Also  $\theta_1$  is a function of the index of refraction and of the geometry of the instrument. A satisfactory procedure for determining the composite value of *n* cos  $\theta_1$  is to measure the thickness of selected films with an instrument known to give correct values directly, and then compute the value of *n* cos  $\theta_1$  required to give this thickness, using the wavelength data obtained from the interference method. In this work the optical slit microscope described in reference (1) was used for making the direct measurements.

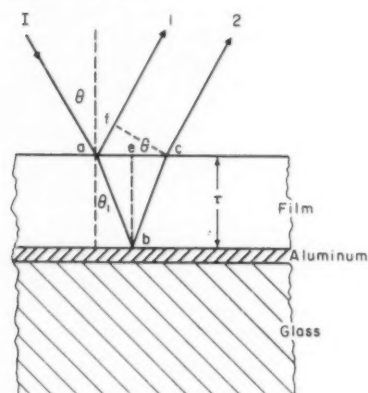


Fig. 1.—Optical path difference between consecutive beams of light reflected from the boundaries of a film.

For the greatest accuracy the value of *n* cos  $\theta_1$  should be established for each type of material being measured.

To calculate the thickness of a film from a curve such as shown in Fig. 2, it is necessary to determine the correct values of *m* to be entered in Eqs. 1 and 2. Although the values of *m* cannot be taken from the curve directly, the difference in the value of *m* for successive maxima or minima is always one. To

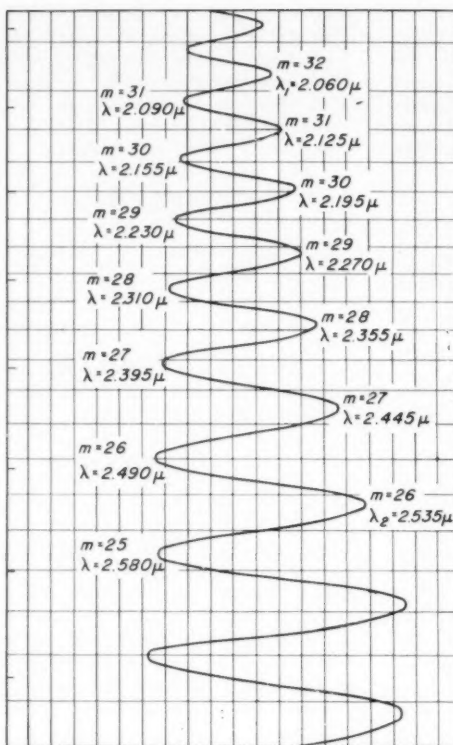


Fig. 2.—Typical curve for calculating thickness by infrared interferometry method showing *m* values and wavelengths of several maxima and minima.

determine the proper value of *m*, any convenient group of interference fringes is chosen so that the end fringes are not in regions where absorption has occurred. Then letting

$\Delta N$  = number of maxima minus one, or the number of minima in the group,

$\lambda_2$  = longest wavelength at which a maximum occurs in the group, and

$\lambda_1$  = shortest wavelength at which a maximum occurs in the group, it can be shown (Appendix II) that:

$$m_1 = \frac{\Delta N \lambda_2}{\lambda_2 - \lambda_1} \dots \dots \dots (3)$$

where *m*<sub>1</sub> is the correct value to be used with the maximum having wavelength  $\lambda_1$ .

The nearest whole number for *m* should be selected. The values of *m* decrease by one for successive maxima in the direction of longer wavelength. The values of *m* assigned to minima are always one less than the *m* value of the preceding maximum (Fig. 2). Thickness values for a convenient number of maxima and minima are calculated and averaged. No fringe deformed by ab-

sorption is used in the calculations.

In some cases the first calculated value of *m* may be approximately halfway between two whole numbers making it impossible to assign the correct value of *m*. To overcome this difficulty, several different groups of fringes are selected, and individual *m* values are calculated for each group. The most probable value (mode) of *m* is selected from this group of values.

## Sample Preparation

Front surface mirrors prepared by evaporating either silver or aluminum onto ordinary plate glass are a very satisfactory substrate for pigmented materials.

Clear films cannot be measured over either aluminum or silver mirrors. To obtain satisfactory interference fringes, beams 1 and 2 of Fig. 1 should have about the same intensity. With clear films over aluminum or silver this is impossible. Beam 1 is always weak, about 4 per cent of *I*, while beam 2 will be large since only a small fraction will be lost in the film by absorption, and both aluminum and silver are almost perfect reflectors of infrared radiation. However, silicon mirrors or graphite applied to plate glass from an oil dispersion are satisfactory as they reflect only 25 to 50 per cent of the infrared radiation. Pigmented films give good results over aluminum or silver because only a portion of the infrared radiation is transmitted.

Materials can be satisfactorily applied by doctor blading. For satisfactory results the films must have parallel surfaces, and surface roughness should be kept to a minimum.

Maximum accuracy and reproducibility require mirror-smooth substrates. However, for pigmented materials, ordinary sheet aluminum and steel have been used with only a small sacrifice of accuracy and reproducibility.

## Testing Procedure

Any infrared or near infrared spectrophotometer which can be equipped with a reflectance attachment is satisfactory for making these measurements. The specimen to be measured is placed on the reflectance attachment and the instrument operated in the usual fashion.

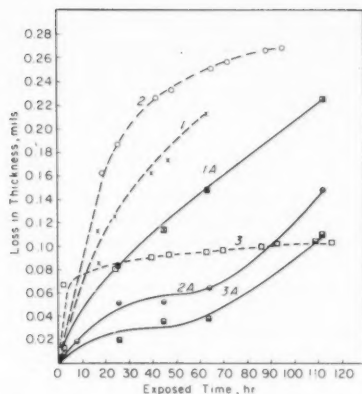


Fig. 3.—Loss of thickness versus time for various clear and pigmented polymeric materials

### Results—Absolute Accuracy

Averages of replicate thickness measurements using the infrared technique are compared with values obtained by direct measurement using an optical slit microscope described in an earlier paper (1). The direct method is less sensitive than the infrared technique and it is destructive. The accuracy of the infrared technique is greatly reduced by the use of a rough substrate such as bonderized steel.

### Applications

The infrared technique has been used for studying the loss of film thickness (degradation) of various polymeric materials both clear and pigmented. The materials were exposed to the unfiltered radiation of a UA-11 lamp, and the loss of film thickness with time was measured. In Fig. 3 curves 1, 2, and 3 represent clear systems while 1A, 2A, and 3A represent the same systems pigmented. The results show this method to be very satisfactory for measuring loss of film thickness due to degradation. It detected large differences between different polymeric systems and also demonstrated the protection afforded by pigmentation of the same systems.

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TABLE I.—ACCURACY OF THICKNESS MEASUREMENTS USING INFRARED RADIATION.

Material	Substrate	Thickness, mils		
		Optical Slit Microscope	Infrared Calculations	Difference
1...	Aluminum mirrors	0.12	0.104	-0.016
2...	Aluminum mirrors	0.13	0.123	-0.007
3...	Aluminum mirrors	0.28	0.276	-0.004
4...	Aluminum mirrors	0.43	0.418	-0.012
5...	Aluminum mirrors	1.05	1.115	+0.065
6...	Aluminum mirrors	0.67	0.654	-0.016
7...	Aluminum mirrors	1.86	1.900	+0.040
8...	Aluminum mirrors	0.80	0.763	-0.037
9...	Aluminum mirrors	0.78	0.844	+0.064
10...	Aluminum mirrors	0.32	0.281	-0.039
11...	Aluminum mirrors	0.74	0.756	+0.016
12...	Aluminum mirrors	0.31	0.296	-0.014
13...	Aluminum mirrors	2.44	2.381	-0.059
14...	Aluminum mirrors	0.78	0.797	+0.017
15...	Sheet aluminum	1.19	1.157	-0.033
16...	Sheet aluminum	2.20	2.210	-0.010
17...	Sheet aluminum	1.19	1.190	0.000
18...	Bonderized steel	1.14	1.178	+0.038
19...	Bonderized steel	2.03	2.100	+0.070
20...	Bonderized steel	1.26	1.47	+0.210

Standard deviation: optical slit microscope = 0.05 mils.  
Standard deviation: infrared interferometry = 0.008 mils.

### APPENDIX I

#### DERIVATION OF EQUATIONS 1 AND 2

The conditions necessary for constructive or destructive interference of beams 1 and 2 shown in Fig. 1 are determined by the phase difference between the two beams.

The phase difference results from the unequal path lengths the two beams travel as well as the environment through which they travel.

The phase at any point in space is equal to  $\frac{2\pi}{\lambda}$  times the path length. The phases of beams 1 and 2 at point *a* are the same; however, at points *f* and *c* they are different.

The phase of beam 1 at point *f* is

$$\phi_1 = \frac{2\pi af}{\lambda} + \pi,$$

$\pi$  must be added because there is a 180 deg change of phase due to reflection at point *a*.

$$af = ac \sin \theta,$$

$$ac = 2ae = 2t \tan \theta_1,$$

$$\sin \theta = n \sin \theta_1,$$

$$\phi_1 = \frac{4\pi tn}{\lambda} \tan \theta_1 \sin \theta_1 + \pi, \text{ and}$$

$$\phi_1 = \frac{4\pi tn \sin^2 \theta_1}{\lambda \cos \theta_1} + \pi.$$

The phase at *c* is

$$\phi_2 = \frac{2\pi}{\lambda/n} (2ab) + \pi$$

since the wavelength in the film is  $\lambda/n$  and there is a change of phase due to reflection at point *b*. Therefore,

$$\phi_2 = \frac{2\pi n}{\lambda} \left( \frac{2t}{\cos \theta_1} \right) + \pi,$$

$$\phi_2 - \phi_1 = \frac{4\pi nt}{\lambda} \cos \theta_1.$$

For constructive interference to occur

$$\phi_2 - \phi_1 = 2m\pi, \text{ where } m = 0, 1, 2, 3 \dots$$

$$2m\pi = \frac{4\pi nt}{\lambda} \cos \theta_1, \text{ and}$$

$$t = \frac{m\lambda}{2n \cos \theta_1} \dots \dots \dots (1)$$

For destructive interference to occur

$$\phi_2 - \phi_1 = (2m + 1)\pi, m = 0, 1, 2, 3 \dots$$

$$\frac{4\pi nt}{\lambda} \cos \theta_1 = (2m + 1)\pi, \text{ and}$$

$$t = \left( \frac{2m + 1}{4n \cos \theta_1} \right) \lambda \dots \dots \dots (2)$$

### APPENDIX II

#### DERIVATION OF EQUATION 3

$$\Delta N = m_1 - m_2,$$

$$\text{since } t = \frac{m_1 \lambda_1}{2n \cos \theta_1} = \frac{m_2 \lambda_2}{2n \cos \theta_1} = \text{etc},$$

$$\Delta N = \frac{2nt \cos \theta_1}{\lambda_1} - \frac{2nt \cos \theta_1}{\lambda_2},$$

$$t = \frac{\Delta N}{2n \cos \theta_1} \left( \frac{\lambda_2 \lambda_1}{\lambda_2 - \lambda_1} \right),$$

$$\frac{m_1 \lambda_1}{2n \cos \theta_1} = \frac{\Delta N}{2n \cos \theta_1} \left( \frac{\lambda_2 \lambda_1}{\lambda_2 - \lambda_1} \right), \text{ and}$$

$$m_1 = \frac{\Delta N \lambda_2}{\lambda_2 - \lambda_1} \dots \dots \dots (3)$$



# The Determination of Alkyl Aryl Sulfonates by Ultraviolet Absorption

By R. M. KELLEY, E. W. BLANK, W. E. THOMPSON, and R. FINE

THE postwar acceptance of synthetic detergents at the expense of soaps has led to the development of many new procedures for the analysis of syndets. Excellent reviews of these analytical methods have been published by Harris and Bernstein (1) and Spangler (2).<sup>1</sup> Among these procedures are several which have had wide acceptance in industry. The para-toluidine method of Marron and Shifferli (3), which has also been studied by Stupel and Segesser (4), offers a useful direct method for obtaining active content. The volumetric methods of Epton (5) and of Barr, Oliver and Stubbings (6) have been studied by many workers and applied successfully. Precipitation and determination of detergents with benzidine has been described by Shiraef (7). Measurements of active content by difference using procedures similar to those described by ASTM<sup>2</sup> have been applied with some success.

Recent investigations on the development of specific methods for alkyl aryl sulfonates in water and sewage have led to the colorimetric methyl-green procedure of Moore and Kolbeson (8), the methylene blue spectrophotometric method of Fairing and Short (9), and the infrared absorption method of the American Soap and Glycerine Producers Assn. Analytical Subcommittee (10).

All of the methods described can be applied to the analysis of detergents containing alkyl aryl sulfonates as the sole active agent, however, application to products containing mixed anionic active ingredients is not practical without employing tedious separation techniques. In a search for a rapid instrumental method specific for alkyl aryl sulfonates in the presence of other detergents, a study of the ultraviolet absorptivity of alkyl aryl sulfonates was made.

Instrumental analysis in the ultraviolet region has been widely used for the quantitative analysis of organic compounds, particularly in the petroleum industry. Several methods have been

published for the analysis of benzene, toluene, xylene, and alkyl benzene in petroleum products (11, 12). The files of the American Petroleum Institute however, gave little, if any, data on the ultraviolet absorption of the high molecular weight sulfonates. Work by Reid, *et al.* (13), demonstrated the use of ultraviolet spectra for the qualitative identification of alkyl aryl sulfonates, however, no mention of quantitative application was made.

Ultraviolet curves for a typical alkyl aryl sulfonate in aqueous solution are shown in Fig. 1(a). Substitution of the sulfonate and alkyl groups on the phenyl chromophore results in an extremely strong absorption in the 210-230 m $\mu$  region. The absorption in this region is so pronounced that a dilution to approximately 11 ppm concentration is necessary to keep absorbance readings on scale when using the Cary Model 11 Spectrophotometer with a 5 cm cell. Absorption is apparent in the 250-270 m $\mu$  region at a concentration of 100

ppm. This absorption becomes quite insignificant when a solution of low concentration is used to permit on-scale readings of the 224 m $\mu$  peak. These absorption characteristics indicate the possibility of applying the intense absorption in the 210-230 m $\mu$  region to the development of a specific quantitative method for alkyl aryl sulfonates.

Examination of the 210 to 230 m $\mu$  region indicates this characteristic and very strong peak to have a maximum at 224 m $\mu$ . Study of this peak has shown the absorption to be (1) invariant with pH and (2) to conform to Beer's law over the concentration range employed. Cary absorption spectra of several commercially available unbuilt alkyl aryl sulfonates showing the persistence of the sharp band with absorption maximum at 224 m $\mu$  are shown in Fig. 1(b). These findings led to the development of the following method.

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E. W. BLANK, Head of the Analytical Section, Colgate-Palmolive Co., Jersey City, N. J., has developed numerous methods for analyzing soaps and syndets.



WALTER E. THOMPSON, Group Leader, analytical Section, Research and Development Department, Smith, Kline and French Laboratories, Philadelphia, Pa. Infrared and ultraviolet spectroscopic methods for chemical analysis of drugs constitute the principal interest of this author.



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<sup>1</sup> The boldface numbers in parentheses refer to the list of references appended to this paper.

<sup>2</sup> Standard Methods of Chemical Analysis of Soaps Containing Synthetic Detergents (D 820), 1958 Book of ASTM Standards, Part 10.

## Apparatus

1. (a) *Photometer*.—A Beckman photoelectric quartz spectrophotometer, Model DU, Catalog No. 2400; cell compartment assembly, Catalog No. 2510-72, and ultraviolet accessory set, Catalog No. 2960, Beckman Instruments, Inc., South Pasadena, Calif. The hydrogen discharge lamp which is included in the ultraviolet accessory set is listed under Catalog No. 2230.

Other suitable spectrophotometers may also be used.

(b) *Absorption Cells*, quartz, matched pairs of optical path length  $1.000 \pm 0.005$  cm. The cells in a pair, when filled with distilled water, should match within 1 per cent transmittance at 224  $m\mu$ . Otherwise, calibrate the cells as directed in Beckman Manual No. 305, 1954, and use a correction factor for each cell. Either Beckman No. 2300-10-89 cells or 1-cm silica cells made by the Pyrocell Manufacturing Co.<sup>3</sup> are satisfactory.

Before each day of operation, load the quartz cells with distilled water and make certain that the cells match within 1 per cent transmittance. This practice is necessary to check cleanliness of the cells. Clean cells, if necessary, using dichromate cleaning solution, until the desired transmittance is obtained (Note 1).

NOTE 1.—All glassware must be rinsed with freshly prepared distilled water before use. Do not dry the rinsed glassware. This is necessary, especially after the first dilution, to avoid errors due to contamination.

## Solvent

2. *Ethyl Alcohol (95 per cent)*.—Either Formula No. 3A or No. 30 of the U. S. Bureau of Internal Revenue may be employed.

## Procedure

3. (a) *Powders and Solid Samples*.—Weigh, to the nearest 0.1 mg., 0.9 to 1.1 g. of a representative sample. Dissolve the sample in water (Note 2) and dilute to 500 ml with water at room temperature, employing a 500-ml. volumetric flask. Mix well.

NOTE 2.—The sample must be completely dissolved if satisfactory results are to be obtained. Suggested procedures for dissolving the sample are:

(1) Transfer the weighed sample to the volumetric flask and dilute to volume with water at room temperature. Carefully insert a Teflon covered stirring magnet and agitate vigorously on a magnetic stirrer for 15 to 20 min. Carefully invert the flask several times to insure thorough mixing. Continue with the regular procedure beginning with Section 3 (c).

(2) Transfer the weighed sample to a 600-ml beaker. Add 200 ml of water and place on a steam bath or hot plate for about 10 min with occasional stirring. Cool to room temperature, dilute to volume, and continue with the regular procedure beginning with Section 3 (c). A fine stream of water or a few drops of alcohol will aid in breaking any foam persisting in the neck of the volumetric flask.

(b) *Slurry Samples*.—Weigh, to the nearest 1 mg, approximately 20 g of a representative sample. Add 50 ml of alcohol and mix to disperse the sample. Dissolve the sample in water (Note 2) and dilute to 1000 ml with water at room temperature, employing a 1000-ml volumetric flask. Mix well.

<sup>3</sup> Pyrocell Manufacturing Co., 207 East 84th St., New York, N. Y.

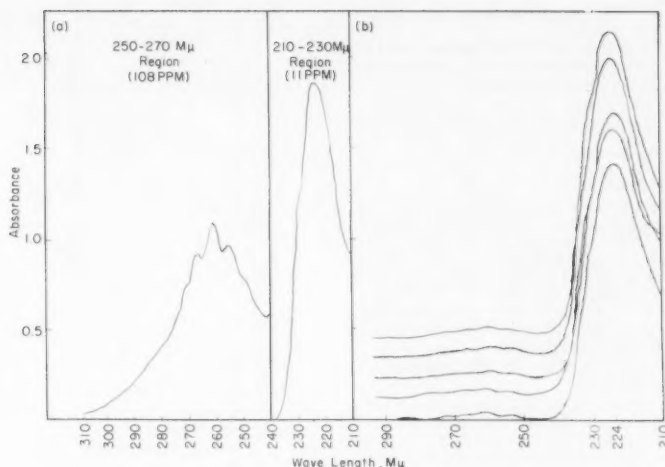


Fig. 1.—Ultraviolet absorption of alkyl aryl sulfonates.

Pipet a 50-ml aliquot into a 500-ml volumetric flask, dilute to volume with water at room temperature, and mix well.

(c) Pipet a 5-ml aliquot of the solution from Paragraph (a) or (b) into a 250-ml volumetric flask and dilute to volume with water at room temperature. Mix well.

(d) Using 1-cm cells in the Beckman spectrophotometer, measure the absorbance at 224 and 270  $m\mu$  versus a water blank. There is danger of contamination of the sample with regular production detergent dust in the laboratory air; therefore these measurements must be made immediately after the step described in Paragraph (c). Contamination is evident when a high reading (above 0.1 absorbance) at 270  $m\mu$  is obtained. Discard such contaminated samples and start with a new aliquot Paragraph (c). (Notes 3, 4, and 5.)

NOTE 3.—The observed absorbance readings should be between 0.2 and 0.8; otherwise weigh a new sample or take a new or different aliquot and dilute to a known volume. (See also Note 6.)

NOTE 4.—When analyzing samples of doubtful origin, the absorption maximum at 224  $m\mu$  should be checked. Measure the absorbance at 220, 224, 228, and 270  $m\mu$ . The absorbance at 224  $m\mu$  should be greater than the absorbance at either 220  $m\mu$  or 228  $m\mu$ . If the 224- $m\mu$  absorption is not the maximum of all the absorbance readings, alkylbenzene sulfonate is not responsible for the observed absorption and the spectrophotometric method is invalid.

NOTE 5.—A previously analyzed sample or solution may be used to check performance of the cell and instrument. Guard such reference samples from contamination and renew periodically (quarterly).

(e) *Calculations*.—Calculate the percentage of active ingredient (sodium alkylbenzene sulfonate) as follows (Note 6):

Active ingredient (Na alkylbenzene sulfonate)

$$= \frac{A_{224} - A_{270} \times 100 \times 25}{W \times a}$$

where:

$A$  = observed absorbance at 224 and 270  $m\mu$ ,

$W$  = grams of sample used (Paragraph (a)) or grams of sample repre-

sented in the aliquot used (Paragraph (b)), and  
 $a$  = absorptivity value for the particular alkylbenzene sulfonate being determined (Section 6).

NOTE 6.—The calculation as written is based on the diluting and aliquoting scheme as written in Section 3 (a) to (d) and the absorptivity value ( $a$ ) of products made from commercially available dodecyl benzenes. The calculation may be adapted to general use as follows:

Active ingredient (sodium alkylbenzene sulfonate), per cent =  $\frac{A_{224} - A_{270}}{c \times b} \times \frac{100}{a}$

where:

$A$  = observed absorbance,  
 $b$  = cell length in centimeters,  
 $c$  = concentration of final dilution in grams per 1000 ml, and  
 $a$  = absorptivity value.

Due to slight variations between various sulfonates, the absorptivity value,  $a$ , must be determined for each particular sulfonate being analyzed. This is done as follows:

4. (a) Determine the percentage of organic alcohol-soluble matter in the sample under test in triplicate. (Note 7.) The results should agree within 0.5 per cent.

(b) Conduct the spectrophotometric determination of active ingredient in triplicate as described in Sections 1 to 3 and record the absorbance readings at 224 and 270  $m\mu$ .

(c) Calculate the absorptivity value,  $a$ , for each determination (Paragraph (b)) as follows and use the average of the three for analysis:

Absorptivity value,  $a =$

$$\frac{A_{224} - A_{270}}{M_{alc} \times 100}$$

where:

$A$  = observed absorbance  
 $M_{alc}$  = percentage of organic alcohol-soluble matter in the sample

(average of three determinations),  
 $b$  = cell length in centimeters, and  
 $c$  = concentration of final dilution in grams per 1000 ml.

NOTE 7.—The organic alcohol-soluble matter (active ingredient by difference) may be calculated from the results obtained on the original sample by the following determination:

**Moisture.**—Methods for Sampling and Chemical Analysis of Alkylbenzene Sulfonates (ASTM Designation: D 1568).<sup>4</sup>

**Alcohol Insoluble Matter.**—Alcohol Soluble and Alcohol Insoluble Matter (AOCS Official Method Da 3-48).<sup>5</sup>

**Sodium Chloride.**—Potentiometric Determination of Chlorides (AOCS Tentative Method Db 7b-55).<sup>5</sup>

**Un sulfonated Material (Neutral Oil).**—Method D 1568.<sup>4</sup>

From the results obtained in the above determinations, the percentage of alcohol-soluble matter (sodium alkylbenzene sulfonate) may be calculated as follows:

Alcohol-soluble matter (sodium alkylbenzene sulfonate), per cent  
 $= 100 - (M_i + A + B + C)$

where:

$M_i$  = percentage of alcohol-insoluble matter,  
 $A$  = percentage of moisture,  
 $B$  = percentage of sodium chloride, and  
 $C$  = percentage of neutral oil.

The high dilution necessary because of the strong absorption of the alkyl benzene sulfonates has been found at times to cause errors due to contamination unless extreme cleanliness is exercised. To surmount this difficulty, a quartz flow cell has been utilized that helps to eliminate the interference by permitting use of higher concentrations. The flow cell in use at present has an effective light path of approximately 0.030 cm and can be inserted in the spectrophotometer in tandem with the regular cell assembly, thus permitting use of the instrument for other purposes without dismantling.

The construction of the flow cell is shown in Fig. 2. The Beckman cell holder was modified slightly to accommodate the cell. In usage, the absorbance readings are taken as the solution flows through the cell from bottom to top. A picture of the flow cell showing its position in the instrument cell holder is given in Fig. 3. This arrangement is especially adapted for routine rapid control testing.

The simplified procedure using the flow cell is as follows:

Weigh to the nearest 0.0001 g a portion of the sample containing 0.3 to 0.5 g of alkyl aryl sulfonate. Dissolve the sample in water and dilute to 1000 ml in a volumetric flask. Rinse the flow cell with water and fill the funnel with water. Set the wave-length dial at 224

<sup>4</sup> 1958 Book of ASTM Standards, Part 10.  
<sup>5</sup> Official and Tentative Methods of the American Oil Chemists' Society, Second Edition (including latest revisions).

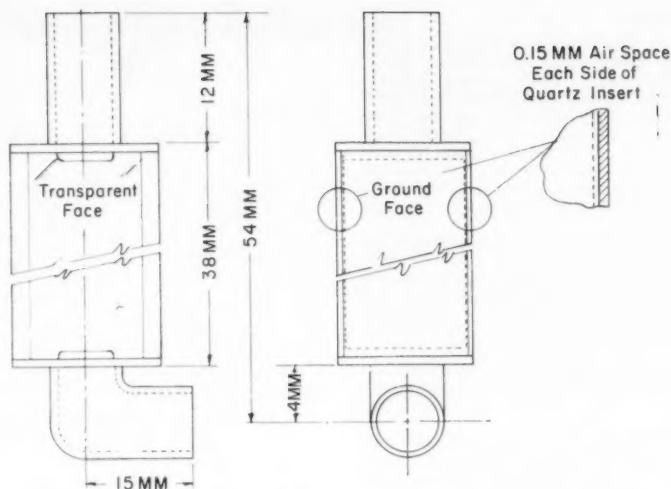


Fig. 2.—Flow cell construction.

$m\mu$  and zero the instrument using the dark current knob with the shutter off and the selector switch on check. Using standard operating procedure adjust the instrument to zero absorbance with water flowing through the flow cell. Rinse the funnel and flow cell with approximately 50 ml of the detergent solution and measure the absorbance with the solution flowing through the cell. Repeat the operation with water and the sample solution at 270  $m\mu$  and calculate the alkyl aryl sulfonate content as follows:

Alkyl aryl sulfonate, per cent =

$$\frac{(A_{224} - A_{270})}{W \times b \times a} \times 100$$

where:

$W$  = weight of original sample, and  
 $b$  = cell path in cm. This must be known accurately and may be determined by calibration with solutions of known active content or by comparison with a standard cell.

The method has been applied successfully to a wide variety of detergents containing alkyl aryl sulfonates. Tables I and II give results of analysis of several commonly encountered commercial detergents by both the proposed method and alternate procedures.

Dishwashing compounds, liquid detergents, and all types of industrial

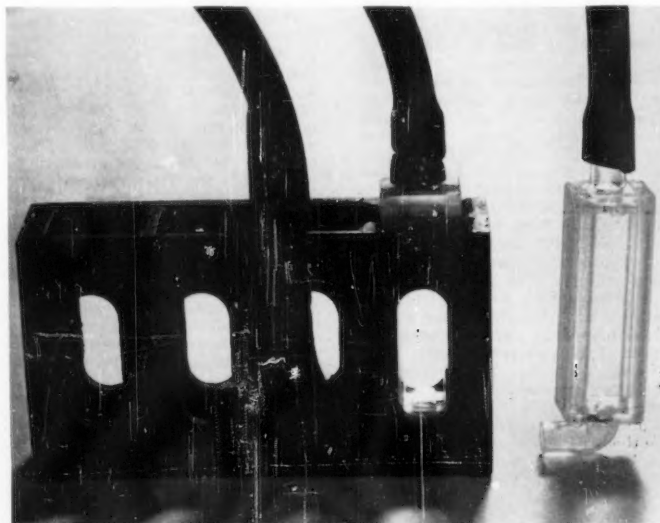


Fig. 3.—Arrangement of flow cell in instrument cell holder.



TABLE I.—PERCENTAGE OF ALKYL ARYL SULFONATE FOUND IN DETERGENT BASE.

Sample	Type of Active Ingredients in Sample	UV Method	Alternate Method
No. 1.....	Alkyl Aryl sulfonate only	26.6	26.9
No. 2.....	Mixed alkyl aryl sulfonate plus alcohol sulfate	42.2	42.6
No. 3.....		10.9	10.8
No. 4.....	Alkyl aryl sulfonate only	10.8	11.3
No. 5.....		42.4	42.2
No. 6.....		40.1	39.7

specialty detergents have been successfully analyzed using this method. In addition, it has also been found to be a useful tool for the qualitative identification of alkyl aryl sulfonate. For this purpose, the use of a recording spectrophotometer is recommended. The excellent work of Reid, *et al.* (13) is of interest along this line.

Interference can be expected from any material showing strong absorption in the 220 to 230  $m\mu$  region. Thus, such materials as benzene, toluene, and xylene sulfonates which are used in some alkyl aryl sulfonate formulations cause a positive interference. The non-ionic alkyl phenoxypolyoxyethylene ethanol types and their anionic sulfate ester derivatives also have strong absorptions in the working region. In many cases it has been found that the alkyl aryl sulfonate can be separated from the interference, permitting application of the method. The low molecular weight sulfonates can be separated from the alkyl aryl sulfonate by an ether extraction from acidified solution, as described by House and Darragh (14). Use of ion exchange resins has proved to be a useful tool in the separation from interfering nonionics. Application of differential instrumental techniques has been used in some cases where interference occurs.

In studies of application to heavy duty detergents, the method has proved to be valid as the absorption of phosphates, silicates, carbonates, and carboxymethyl cellulose has been found to be low. The high dilution used in the analysis has been successful in repressing interferences from many materials,

TABLE II.—PERCENTAGE OF ALKYL SULFONATES FOUND IN DETERGENT SAMPLES

Sample	UV Method	Alternate Method
Unbuilt Detergents		
No. 1.....	32.2	32.2
No. 2.....	33.8	33.5
No. 3.....	31.9	31.9
No. 4.....	31.8	32.0
No. 5.....	40.2	39.8
Built Detergents		
No. 1.....	33.4	33.9
No. 2.....	35.2	35.4
No. 3.....	34.7	34.8
No. 4.....	28.9	28.7
No. 5.....	18.2	17.8
No. 6.....	17.0	17.4
No. 7.....	18.4	18.7
No. 8.....	12.8	13.2
No. 9.....	21.2	21.5
Cleansers		
No. 1.....	3.8	3.7
No. 2.....	4.0	4.0
No. 3.....	3.7	3.7
No. 4.....	3.5	3.4
No. 5.....	4.4	4.4
No. 6.....	4.1	4.4

such as optical dye, unreacted oil, and the ethanolamide additives. Curves for the latter run at approximately the same concentration used for the alkyl aryl sulfonate samples indicate this interference to be negligible in that the additives are usually kept at a ratio of 20 to 30 per cent alkyl aryl sulfonate to 1 to 3 per cent additive in most formulations. Alkyl sulfates offer no interference. In general, the presence of any other detergent or compound containing the phenyl chromophore will cause positive interference. Examination of the sample by other means, such as chemical test, infrared, or, at times, a complete ultraviolet curve will help characterize the nature of the active agents present and permit possible application of the method.

Because the method is rapid and does not require a high degree of skill in routine operation, it is well suited for production control analysis. (The procedure has been used with success in the authors' laboratories for an extended period with excellent results.) Application of the basic technique to plant stream analyzers appears feasible.

The authors wish to express their thanks to Mr. A. P. Kent for his significant contribution to this work and to Mr. R. I. Ward for his design of the flow cell.

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# Analysis of Commercial Sodium Tripolyphosphate by Reverse Flow Ion Exchange Chromatography

By R. H. KOLLOFF

IN THE PAST few years the exact composition of commercial sodium tripolyphosphate (STP) has become increasingly important in the manufacture and performance of synthetic detergents. This has resulted in the demand for a relatively fast and precise method for determining directly the tripolyphosphate content and associated impurities.

Commercial sodium tripolyphosphate generally contains 85 per cent or more anhydrous sodium tripolyphosphate ( $\text{Na}_5\text{P}_3\text{O}_{10}$ ), 4 to 15 per cent tetrasodium pyrophosphate ( $\text{Na}_4\text{P}_2\text{O}_7$ ), 0.1 to 1.0 per cent of orthophosphate ( $\text{Na}_3\text{PO}_4$ ) and up to 4.0 per cent trimetaphosphate ( $\text{Na}_3\text{P}_3\text{O}_9$ ). Tetrametaphosphate and long chain polymeric phosphates are seldom found.

Many recent modifications of three different analytical approaches (1-9)<sup>1</sup> have been published, but all of these have disadvantages for use in a control laboratory. With one exception the methods are too slow for routine work. Weiser's method (6), which precipitates STP with triethylene diamine cobalt chloride, is fast and will give moderately accurate results when test conditions are carefully controlled, but unfortunately the minor constituents are not determined.

Paper chromatography (8), which has been extensively used for control work, gives a complete analysis and precision is good. Although two days are required for a complete analysis of four to six samples, this procedure, until now, has been the best available quantitative analytical method.

The separation of the various phosphate species by ion exchange and subsequent colorimetric measurement (1-5, 9) gives a complete and fairly precise analysis, but the procedure is too time consuming by control laboratory standards. An ion exchange method published recently (9) is lengthy, as compared to paper chromatography, and a recent evaluation of the method (10) shows erratic results using downward

elution, resulting in poorer precision than desired.

The ion exchange chromatographic method presented in this paper utilizes studies previously published (1-5) and employs a continuous gradient (1, 7), pressurized, "upflow" elution. In the present work it was found that a major cause of poor precision in ion exchange analyses is the erratic and incomplete recovery of the phosphate species from the column. This problem has been solved by reversing the flow of the eluant through the column and using an extremely fine mesh, tightly packed resin bed. The pressurized, reverse flow pattern works to prevent channeling and eliminates eluant convection currents in the resin bed. This is the key to complete recovery of each species from the column in its proper fraction. This procedure gives the complete composition of commercial STP and is about twice as fast (1.33 man-hours per sample) as paper chromatography. Four to six complete analyses can be made in one 8-hr day. The method is twice to three times as fast as the most rapid ion-exchange procedure published to date. We believe this method is the most precise analytical technique available for assaying phosphate mixtures in the control laboratory.

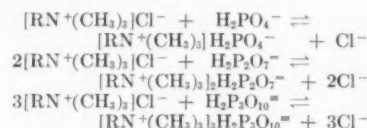
## Principle of Method

A solution of commercial STP is placed in a resin column, and the species fractionated by means of a pressurized, continuous-gradient, reverse flow elution. A quantitative determination of the eluted phosphate species is made by an improved molybdenum blue colorimetric method based on previous publications (11, 12, 13). Only one fraction is collected and analyzed for each species.

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The principle of the continuous-gradient elution technique has been discussed previously (1, 7).

The following equations probably represent the predominating equilibria found at a pH of about 5.0. Before elution the equilibrium is shifted to the right; during elution the equilibrium shifts to the left:



The order of elution is (1) *ortho*, (2) *pyro*, (3) *tripoly*, (4) *tetrameta*, and (5) *trimeta*. Long chain phosphates are not displaced.

## Scope

This method can be used to analyze completely any mixture of low molecular weight phosphates including *ortho*, *pyro*, *tripoly*, *tetrameta*, and *trimeta*. The higher molecular weight phosphates can only be determined by difference if the procedure is followed as given here. This method is specifically designed for completely analyzing commercial STP.

## Experimental Procedure

### Reagents

- Ion Exchange* (use ACS reagent grade chemicals).—(a) 1 M hydrochloric acid; (b) Stock buffer solution—0.80 M potassium acetate adjusted to pH 5.0 with glacial acetic acid; (c) 1.0 M potassium chloride—buffer at pH 5.0 by adding 100 ml of stock buffer solution to every 16 liters; (d) 0.10 M potassium chloride—buffer at pH 5.0 as with 1.0 M potassium chloride; and (e) Ion exchange resin—Dowex 1X-10, 200 to 400 mesh, chloride form, capacity of 3.2 milliequivalents per dry gram.<sup>2</sup>

### Preparation of resin:

(1) Allow about  $\frac{1}{2}$  lb of crude resin per column. Make a 2 to 1 slurry of water and resin and decant off fines. Repeat procedure until supernatant liquid remains clear;

(2) Make a 3 to 1 slurry of water and resin, allowing oversize particles and any foreign material to settle; decant off main slurry of water and resin, saving this portion and discarding residue in

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<sup>1</sup> The boldface numbers in parentheses refer to the list of references appended to this paper.

<sup>2</sup> Obtainable from either Dow Chemical Co. or Bio-Rad Laboratories.

bottom of beaker; repeat until resin is free of oversize particles and foreign material;

(3) Soak sized resin in 1 *M* hydrochloric acid for a minimum of 48 hr. Decant supernatant acid twice each day adding fresh acid and reslurrying after each decantation; and

(4) After packing the resin in the chromatographic columns, run hydrochloric acid under pressure through the resin until the eluate shows no foam upon shaking and is free from odor other than that normal to hydrochloric acid. One liter or more of hydrochloric acid should be used.

**Colorimetric  $P_2O_5$  Determination.**—(a) Reducing solution, 0.15 per cent—work in absence of direct ultraviolet light (fluorescent, daylight);

(1) Purify amino-naphthol-sulfonic acid by dissolving 15 g crude 1-amino-2-naphthol-4-sulfonic acid (Eastman) in 1 liter of water at 90 C containing 150 g reagent grade  $NaHSO_3$  and 10 g reagent grade  $Na_2SO_3$ ; filter while hot through fast (coarse) filter paper; cool to room temperature and add 10 ml concentrated hydrochloric acid; filter off crystals, washing first with water, then  $CH_3OH$ ;

(2) Dissolve 1.500 g of the recrystallized 1-amino-2-naphthol-4-sulfonic acid in 75 ml of water containing 7 g  $Na_2SO_3$ ; and

(3) Dissolve 90 g reagent grade  $NaHSO_3$  in 700 ml of water and mix with solution of amino-naphthol-sulfonic acid from (2); dilute to 1000 ml in a volumetric flask; solution is stable for about 1 month when protected from ultraviolet light.

(b)  $(NH_4)_6Mo_7O_{24} \cdot 4H_2O$ , 10 per cent aqueous solution;

(c) Sulfuric acid, 8*N*; and

(d) Standard orthophosphate solution and standard curve. Dissolve 1.9172 g dry ACS reagent grade  $KH_2PO_4$  in water and dilute to 1000 ml in volumetric flask (concentration = 1 mg  $P_2O_5$  per ml); make a series of appropriate volumetric dilutions and then a series of aliquots covering a range of 0 to 4  $\mu g$   $P_2O_5$  per ml for the 50 mm cells and 0 to 20  $\mu g$   $P_2O_5$  per ml for the 10 mm cuvettes; develop color as under colorimetric procedure and construct standard curves (see Fig. 1); the reagent blanks and the standards for the curve should be 0.1 *M* in potassium chloride.

#### Apparatus

**Colorimeter.**—Fisher Electrophotometer (or equivalent) equipped with a 650  $m\mu$  filter, 10 mm inside diameter cylindrical cuvettes and rectangular cells with 50 mm path length.

**Equipment.**—As shown in Figs. 2, 3, and 7 including the following:

(a) Tube, chromatographic; 20 mm inside diameter by 400 mm length,

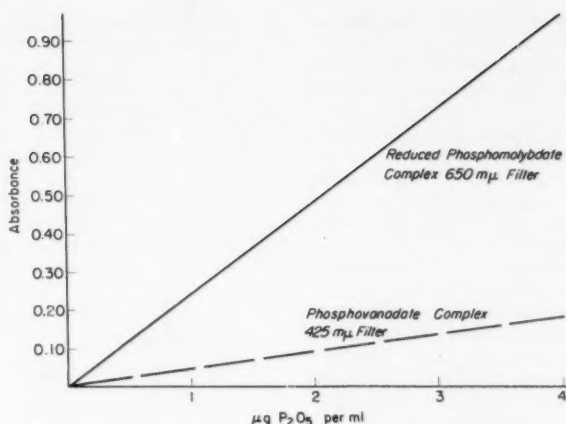


Fig. 1.—Standard colorimetric curves 50 mm rectangular cells.

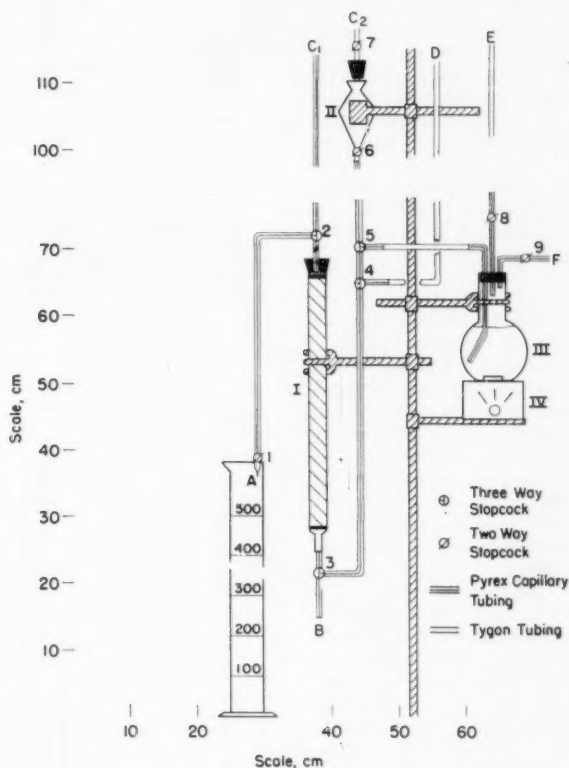


Fig. 2.—Column construction details.

- I. Chromatographic tube containing packed resin bed approximately 37 cm in height;
  - II. Sample funnel;
  - III. 1 liter mixer, initially containing 0.1 *M* potassium chloride; and
  - IV. Magnetic stirrer.
1. Sample addition: Place sample aliquot in II. Flow is through 6, 5, 4, 3, 2, 1 and out at A;
  2. Sample elution (upflow): Flow is from 1.0 *M* potassium chloride carboy through E, 8, III, 5, 4, 3, 2, 1 and out at A; magnetic stirrer IV is on at all times;
  3. Column regeneration (upflow): Flow is from 1.0 *M* hydrochloric acid carboy and through 4, then up through 3, 2 and out at A;
  4. Column wash
- Downflow:**  
Flow is from distilled water carboy through C, 2, 3, and out at B. Also rinse tube from 2 through 1 and out at A, and flush manifold;  
**Upflow:** Flow is through C, 7, 6, 5, 4, 3, 2, 1, and out at A.



Pyrex glass with fritted glass disk at bottom;

(b) Tubing, capillary, Pyrex glass;  $1\frac{1}{2}$  mm inside diameter, 7 mm outside diameter;

(c) Tubing, Tygon,  $\frac{1}{4}$  in. inside diameter,  $\frac{3}{8}$  in. outside diameter;

(d) Flask ("mixing"), flat bottom, ring neck, Pyrex glass, 1000 ml;

(e) Carboys, 5 gal, Pyrex glass, wide mouth (No. 12 stopper) for 1.0 M potassium chloride, 1.0 M hydrochloric acid, and water; and

(f) Optional solenoid pinch clamp for automatic regeneration; solenoid must be rated as continuous duty; normally closed for operation on 115 to 120 v, 60 cycle ac; use in conjunction with a clock timer, such as Fisher Scientific.<sup>3</sup>

#### Procedure

**Column Packing.**—(a) Clean chromatographic column halfway to top with 1 M hydrochloric acid freeing frit and space below frit of air; fill remainder of column with a 1 to 1 slurry of resin and 1 M hydrochloric acid and immediately pack resin in column by applying vacuum (water aspirator) at the column bottom valve; do not let liquid level in column fall below resin level, let air become entrapped in resin bed, or vaporize the water in the resin bed by applying too much vacuum; continue procedure until packed resin bed reaches column shoulder (approximately 37 cm); and

(b) Place mat of glass wool on top of bed and firmly seat rubber stopper on top of wool in order to hold bed in place; alternate pressurized upflow and downflow of 1 M hydrochloric acid through resin bed until no further redistribution and contraction occurs (as indicated by disappearance of any void between bed and glass frit); compensation for void may be made by the addition of resin or glass wool; appearance of a large void indicates insufficient vacuum used in packing resin.

**Column Regeneration.**—(a) The column should always be regenerated before analyzing a sample; if the column has been idle for more than a few days since a previous full regeneration, simply use pressurized upflow of 500 ml of 1 M hydrochloric acid through resin before a pressurized washing with water; and

(b) Full regeneration (pressurized). After analysis of each sample and before analysis of next sample, upflow 200 to 300 ml of 1.0 M hydrochloric acid through column and let soak overnight (minimum of 12 hr), then resume regeneration in morning by upflowing 500 ml of 1.0 M hydrochloric acid through column (automatic regenerator): wash column (downflow) with

<sup>3</sup> Catalog No. 6-657.

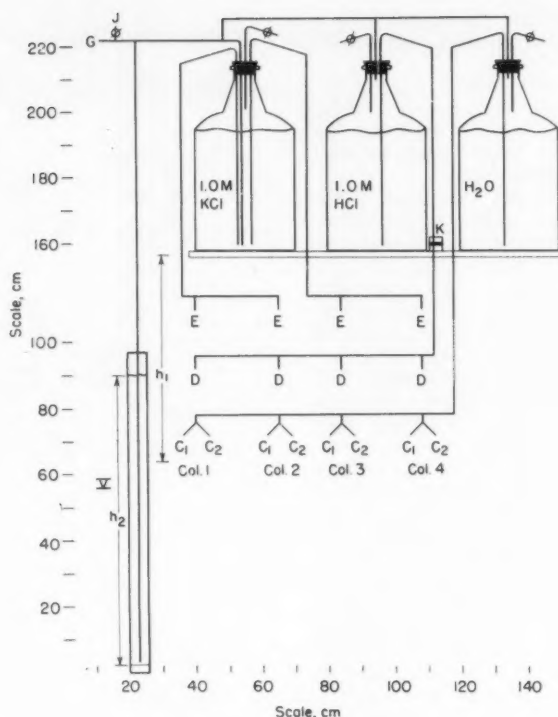


Fig. 3.—Pressurized feed system.

V. Supplementary pressure regulator, optional (17); An open line from air line G is immersed in a column of water V to regulate supplementary application of pressure to columns; supplementary pressure is regulated by adjusting height of water column in V. Flow rate is then regulated by adjusting valve 1. The sum of  $h_1$  and  $h_2$  is proportional to the total pressure applied to the columns and is generally equal to 200 cm for a flow rate of about 6 ml per min.

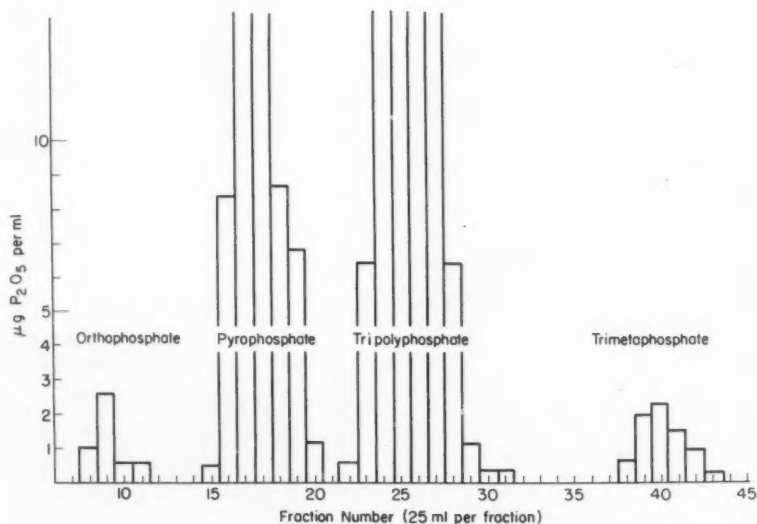


Fig. 4.—Elution curve for continuous gradient upflow elution Dowex 1X-10 200 to 400 mesh.

water until acid free (250 ml), then reverse flow (upflow) and wash with an additional 100 to 200 ml of water; proceed immediately with sample addition after upflow wash.

**Colorimetric Procedure.**—(a) Add 3 ml 8 N  $H_2SO_4$  per 100 ml final sample volume (final acidity = 0.24 N);

(b) If solution contains other than orthophosphate, hydrolyze for 1.5 hr in boiling water bath; cool to room temperature;

(c) Add 1 ml 10 per cent ammonium molybdate per 100 ml final volume (final concentration = 0.10 per cent);

(d) Add 2 ml of 0.15 per cent reducing solution per 100 ml final volume (final concentration = 0.003 per cent); and

(e) Dilute to volume, mix, and develop color at room temperature for 35 min (or until constant absorbancy is obtained); read absorbancy at 650  $m\mu$ . The 10 mm cuvetts are generally used only for the STP fraction.

**Column Calibration.**—This calibration is necessary in order to ascertain exactly when each phosphate species is leaving the column and in what volume it will be contained. Each lot of resin need be calibrated only once, and if all columns of a series contain the same lot of resin, only one column of the series need be calibrated. A large quantity of resin purchased initially will eliminate frequent recalibrations.

(a) Using a reference STP sample representative of the material to be analyzed, follow procedure as under sample analysis below with the following exceptions:

(1) Adjust pressurized flow rate to about 6 ml per min, with a maximum variation of  $\pm 0.25$  ml per min; and

(2) Collect 45 to 46 25-ml fractions (numbered in sequence), and

(b) Analyze fractions colorimetrically and plot  $P_2O_5$  concentration versus fraction number as in Fig. 4; determine volume of eluate in which each species is contained.

**Sample Analysis.**—(a) Regenerate and wash resin; (in steps (a) through (e), refer to Figs. 2, 3, and 7);

(b) Flush manifold system;

(c) Fill mixer with 0.10 M potassium chloride, stopper flask, start stirrer, and equalize pressure (Fig. 7);

(d) Pipet 20 mg sample (0.5000 g into 500 ml volumetric flask, 20 ml aliquot) containing approximately 11 to 12 mg  $P_2O_5$  into funnel and drain into column, rinsing funnel with three 10 ml portions of water; if desired, the sample may be forced in under pressure;

(e) Start pressurized elution, adjusting flow (valve 1, Fig. 2) to rate used in calibration;

(f) Collect phosphate species in respective graduated cylinders, changing receivers when the proper volume (as determined in calibration) has been collected; The first 100 to 150 ml constitute the column blank;

(g) Analyze each fraction colorimetrically; the column blank, *ortho*, tri- and tetrameta fractions need not be transferred from the 250 ml glass stoppered cylinders, but may be hydrolyzed and analyzed in their original containers; The pyro and STP fractions should be transferred to larger volumetric flasks (500 and 1000 ml) to insure ac-

curacy of dilution and to keep the absorbancy on scale; a reagent blank should be run with each series of determinations in order to determine the net absorbance; if the column blank exceeds the reagent blank by more than 0.005 absorbancy units, the calculation should be handled by subtracting the column blank absorbance from that of the *ortho* fraction and subtracting the reagent blank from the rest of the fractions; if the column blank is much higher than the reagent blank (0.02) incomplete regeneration, contamination, or channeling is indicated;

TABLE I.—EXPERIMENTAL DESIGN FOR ANALYSIS OF FOUR COMMERCIAL STP SAMPLES AMONG FOUR RESIN COLUMNS.

	Run	Columns			
		A New Resin	B Old Resin 5 Previous Runs	C New Resin	D Old Resin 10 Previous Runs
Random pattern No. 1	No. 1. ....	IV	III	II	III
	No. 2. ....	II	III	IV	III
	No. 3. ....	III	I	IV	III
	No. 4. ....	III	II	I	IV
	No. 5. ....	IV	II	II	I
	No. 6. ....	II	I	III	II
	No. 7. ....	I	IV	I	IV
	No. 8. ....	I	IV	III	I
	No. 9. ....	I	IV	III	I
	No. 10. ....	IV	I	IV	III
Random pattern No. 2	No. 11. ....	III	III	I	IV
	No. 12. ....	I	IV	III	I
	No. 13. ....	IV	I	IV	III
	No. 14. ....	I	IV	III	I
	No. 15. ....	IV	I	IV	III

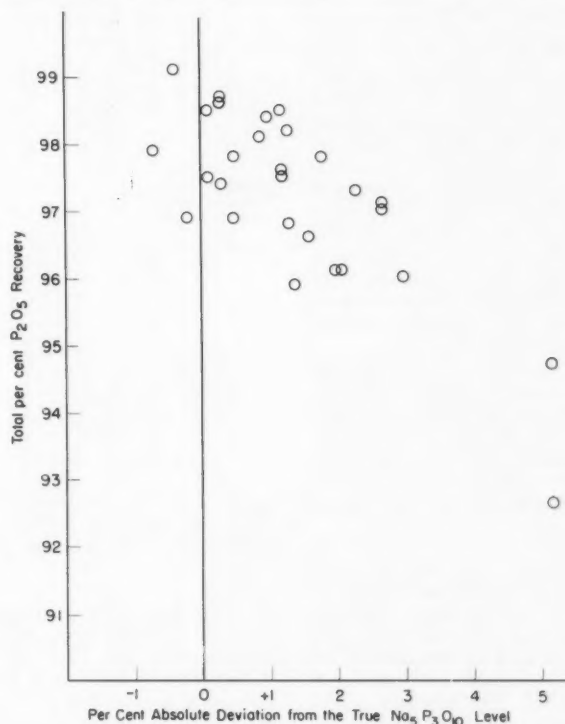


Fig. 5.—Downflow continuous gradient elution.

Samples I, III, IV.

All values found were normalized before calculating deviation from the true level.

(h) In order to accurately calculate the recovery of  $P_2O_5$  from the column and the percentage of each species present, total  $P_2O_5$  is determined on each sample by any standard method such as the volumetric phosphomolybdate procedure (16) and

(i) Calculations:

(1) Determine total  $\mu g P_2O_5$  recovered from column; recovery should equal  $100 \pm 0.5$  per cent; and

(2) Per cent  $P_2O_5$  of total  $P_2O_5$  present as species =  $(\mu g P_2O_5 \text{ of species} / \text{Total } \mu g P_2O_5 \text{ recovered}) \times 100$

Per cent species =  $\{[(\mu g P_2O_5 \text{ of species} / \text{total } \mu g P_2O_5 \text{ recovered}) (\text{total per cent } P_2O_5 \text{ of sample})] / \text{theoretical per cent } P_2O_5 \text{ of species}\} \times 100$

## Experimental Results

### Laboratory A (author)

Conditions as found in a control laboratory were simulated as closely as possible. Deliberate variations in technique, reagent addition, column regeneration, etc., were made. Four samples of STP (I, II, III, IV) were randomized among the four columns as shown in Table I.

The results of these experiments are tabulated in Table II. Performance of the method in laboratory A is summarized in Table IV in terms of a weighted standard deviation.

### Laboratory B (18)

Replicate determinations were performed on four samples by a different analyst with different equipment following the method as written. These results are summarized in Table III. Performance of the method in laboratory B is also tabulated in Table IV.

An analysis of variance was performed on the experimental data from laboratory A. Among columns, resin age and column-resin interaction were tested. None of these error sources were statistically significant.

Although there is insufficient data at present for complete statistical evaluation of inter- and intralaboratory performance, the results reported here strongly indicate that the accuracy and precision will prove to be superior to that of any other known procedure.

### Accuracy

Two approaches were used to check the accuracy of the continuous gradient, reverse flow ion exchange method. Paper chromatography (8) was used as referee method in the analysis of samples of commercial STP numbered I, III, and IV. The excellent agreement between the two independent methods is shown in Table V.

In the other approach, samples V and VI were prepared in laboratories A and

TABLE II.—RESULTS IN LABORATORY A OF EXPERIMENTAL DESIGN OUTLINED IN TABLE I.

SAMPLE I						
Pattern Number	Run Number	Column	Assay, per cent phosphorus of total phosphorus			
			Ortho	Pyro	Tripoly	Trimeta
1	No. 3.....	B	0.52	8.46	89.95	1.07
	No. 4.....	C	0.25	8.07	90.73	0.95
	No. 5.....	D	0.28	8.62	90.0	1.12
	No. 6.....	B	0.38	8.20	90.32	1.10
	No. 7.....	A	0.29	8.15	90.35	1.22
	No. 7.....	C	0.27	8.15	90.60	0.98
	No. 8.....	A	0.29	7.88	90.82	1.01
	No. 8.....	D	0.49	7.90	90.77	0.84
2	No. 10.....	A	0.68	7.81	90.43	1.08
	No. 10.....	D	0.10	7.80	90.95	1.14
	No. 11.....	B	0.43	7.54	90.22	1.81
	No. 12.....	C	0.41	7.96	90.60	1.04
	No. 14.....	A	0.86	7.72	90.40	1.18
	No. 14.....	D	0.90	7.70	90.40	1.20
	No. 15.....	B	0.40	8.27	90.27	1.07
Mean.....			0.4	8.0	90.5	1.1
Standard Deviation, $1\sigma$ .....			0.22	0.29	0.29	0.18
SAMPLE II						
1	No. 1.....	C	0.50	8.64	89.18	1.70
	No. 2.....	A	0.30	8.88	88.82	1.99
	No. 3.....	D	0.53	8.45	88.94	2.07
	No. 4.....	B	0.50	8.72	88.64	2.13
	No. 5.....	B	0.28	8.62	88.98	2.12
	No. 5.....	C	0.25	8.70	89.03	2.02
	No. 6.....	A	0.25	8.36	89.62	1.76
	No. 6.....	D	0.52	8.21	89.92	1.36
Mean.....			0.4	8.6	89.1	1.9
Standard Deviation, $1\sigma$ .....			0.12	0.20	0.39	0.25
SAMPLE III						
1	No. 1.....	B	0.54	6.69	90.95	1.86
	No. 1.....	D	0.43	6.81	90.90	1.85
	No. 2.....	B	0.34	7.44	90.18	2.04
	No. 2.....	D	0.29	7.39	90.26	2.08
	No. 3.....	A	0.63	6.24	91.10	2.03
	No. 4.....	A	0.96	7.08	89.87	2.10
	No. 6.....	C	0.25	6.95	90.90	1.89
	No. 8.....	C	0.24	7.06	91.19	1.52
2	No. 10.....	C	0.30	6.50	91.12	2.08
	No. 11.....	D	0.20	6.66	91.06	2.13
	No. 12.....	A	0.47	7.01	90.00	2.51
	No. 12.....	B	0.53	6.56	90.00	2.95
	No. 14.....	C	0.90	6.78	90.40	1.95
	No. 15.....	D	0.45	7.05	90.15	2.05
Mean.....			0.5	6.9	90.6	2.1
Standard Deviation, $1\sigma$ .....			0.23	0.32	0.46	0.32
SAMPLE IV						
1	No. 1.....	A	0.43	14.47	85.1	0
	No. 2.....	C	0.53	15.18	84.12	0
	No. 3.....	C	0.66	15.55	83.79	0
	No. 4.....	D	0.67	14.94	84.38	0
	No. 5.....	A	0.49	14.77	84.74	0
	No. 7.....	B	0.55	14.51	84.94	0
	No. 7.....	D	0.59	14.55	84.86	0
	No. 8.....	B	0.53	14.60	84.87	0
2	No. 10.....	B	0.82	14.73	84.45	0
	No. 11.....	A	0.54	14.42	85.04	0
	No. 11.....	C	0.52	14.30	85.18	0
	No. 12.....	D	1.0	14.41	84.57	0
	No. 14.....	B	1.4	14.53	84.08	0
	No. 15.....	A	0.56	14.63	84.81	0
	No. 15.....	C	0.46	14.99	84.54	0
Mean.....			0.7	14.7	84.6	..
Standard Deviation, $1\sigma$ .....			0.24	0.32	0.39	..

B, respectively, by mixing known amounts of ortho, pyro, and tripolyphosphates. These data are listed in Tables VI and VII. It is difficult to prepare a pure source of tripolyphosphate and hence the standard source itself ( $Na_5P_3O_{10} \cdot 6H_2O$ ) must be analyzed by the method which is being standardized. The drawback here is obvious.

The best  $Na_5P_3O_{10} \cdot 6H_2O$  the author was able to prepare contained 99.8 per cent of  $Na_5P_3O_{10}$  along with less than 0.1 per cent  $Na_4P_2O_7$  and 0.1 per cent  $Na_3PO_4$ , by ion exchange analysis. Paper chromatography is not sufficiently precise at levels below 0.5 per cent to be of value in this case; however, it gave a relatively close correlation to the above assay.



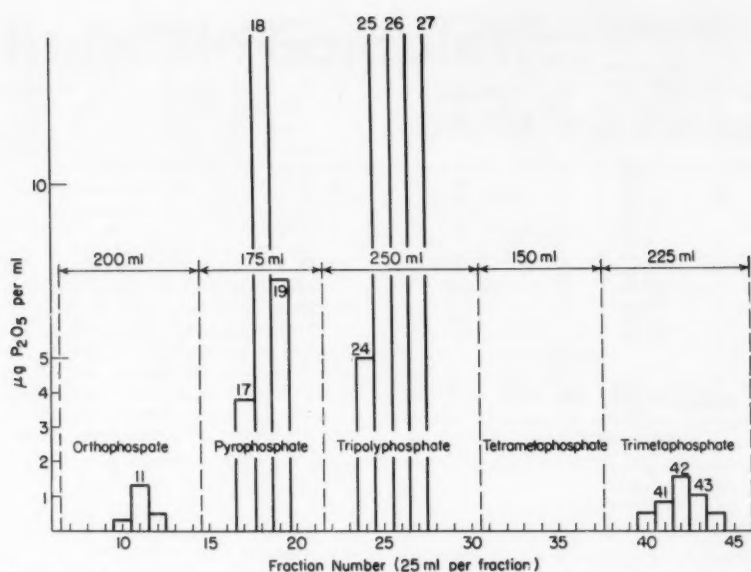


Fig. 6.—Elution curve for continuous gradient downflow elution Dowex 1X-8 100 to 200 mesh.

TABLE III.—RESULTS OBTAINED IN LABORATORY B.

	Assay, per cent phosphorus of total phosphorus			
	Ortho	Pyro	Tripoly	Trimeta
SAMPLE VI				
	0.61	2.25	97.14	0
	0.52	2.28	97.20	0
Mean.....	0.56	2.27	97.17	0
Standard Deviation, 1 $\sigma$ .....	0.06	0.02	0.04	..
SAMPLE I				
	0.44	8.31	90.12	1.13
	0.76	8.20	90.0	1.11
	0.45	8.31	90.1	1.18
	0.32	8.33	90.2	1.14
Mean.....	0.49	8.29	90.11	1.14
Standard Deviation, 1 $\sigma$ .....	0.18	0.06	0.08	0.03
SAMPLE IV				
	0.58	15.02	84.60	0
	0.44	14.87	84.69	0
	0.36	15.12	84.52	0
Mean.....	0.46	15.00	84.60	0
Standard Deviation, 1 $\sigma$ .....	0.11	0.13	0.08	..
SAMPLE VII (Using resin of medium age)				
	0.15	14.87	84.85	0.13
	0.44	14.73	84.72	0.11
	0.50	14.91	84.40	0.19
	0.36	14.94	84.57	0.13
Mean.....	0.36	14.86	84.64	0.14
Standard Deviation, 1 $\sigma$ .....	0.15	0.09	0.19	0.03

TABLE V.—CORRELATION BETWEEN ION EXCHANGE AND PAPER CHROMATOGRAPHY ON COMMERCIAL STP IN LABORATORY A.

Sample	Mean Assay, per cent phosphorus of total phosphorus									
	Ion Exchange				Number of Determinations		Paper Chromatography			
	Ortho	Pyro	Tripoly	Trimeta	Ion Exchange	Paper Chromatography	Ortho	Pyro	Tripoly	Trimeta
I.....	0.4	8.0	90.5	1.1	15	3	0.2	8.2	90.3	0.9
III.....	0.5	6.9	90.6	2.1	14	3	0.2	7.1	90.7	1.8
IV.....	0.7	14.7	84.6	0	15	4	0.8	14.0	85.2	0
Over-all Standard Deviation (1σ) of each method	0.21	0.29	0.39	0.26	..	...	0.3	0.5	0.6	..

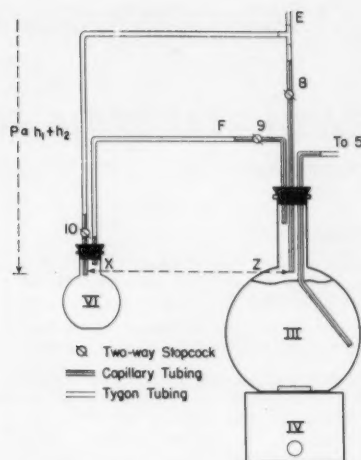


Fig. 7.—Automatic pressure equalizer.

III. Mixer  
IV. Magnetic Stirrer  
VI. Pressure Equalizer Flask

This mixer pressure equalization is performed before sample elution.

1—Apply full pressure to be used during elution to feed system after closing all valves leading to and from mixer, column, and equalizer.

2—Adjust height of empty equalizer bulb (VI) so that X and Z are at the same level (Fig. 7).

3—Open valves 9 and 10, allowing 1.0 M potassium chloride to flow into VI.

4—When the flow ceases, the pressure has been equalized. Close valves 9 and 10 and open valve 8. No 1.0 M potassium chloride should flow through 8 into mixer until sample elution is started by allowing the pressurized 0.1 M potassium chloride to flow from the mixer into the column.

TABLE IV.—WEIGHTED STANDARD DEVIATIONS FOR EACH SPECIES IN THE STP SAMPLES OBTAINED IN LABORATORIES A AND B

Species	Weighted Standard Deviation, per cent phosphorus of total phosphorus	
	Laboratory A	Laboratory B
Ortho.....	0.217	0.142
Pyro.....	0.296	0.087
Tripoly.....	0.385	0.122
Trimeta.....	0.256	0.03

TABLE VI.—SYNTHETIC STP SAMPLE V (LABORATORY A) CONTAINING KNOWN AMOUNTS OF ORTHO, PYRO AND TRIPOLYPHOSPHATES.

	Added (Per Cent Phosphorus of Total Phosphorus)	Recovered (Per Cent Phosphorus of Total Phosphorus)	Difference
Orthophosphate.....	0.6	0.60	0
	0.6	0.64	+0.04
	0.6	0.80	+0.20
Mean.....	0.6	0.68	..
Pyrophosphate.....	4.0	3.76	-0.24
	4.0	4.0	0
	4.0	3.80	-0.20
Mean.....	4.0	3.85	..
Triphosphate.....	95.4	95.64	+0.24
	95.4	95.40	0
	95.4	95.30	-0.10
Mean.....	95.4	95.44	..

TABLE VII.—SYNTHETIC STP SAMPLE VI (LABORATORY B). SAME SAMPLE SOURCES AS LABORATORY A USED.

	Added (Per Cent Phosphorus of Total Phosphorus)	Recovered (Per Cent Phosphorus of Total Phosphorus)	Difference
Orthophosphate.....	0.54	0.61	+0.07
	0.54	0.52	-0.02
	2.32	2.25	-0.07
Pyrophosphate.....	2.32	2.28	-0.04
	97.14	97.14	0
Triphosphate.....	97.14	97.20	+0.06

## Discussion

The reverse flow continuous gradient ion exchange technique is superior to existing methods both with respect to speed and precision. The improvement in analysis time is achieved by a major reduction in the number of fractions to be analyzed; by the utilization of a rapid, pressurized, automatic gradient elution; and by the use of a fast, sensitive, and stable molybdenum blue colorimetric method. Analysis time is one half that of the next fastest method (8), that is four to six complete assays per 8 man-hours when using 4 to 6 columns.

The improved precision is due to the reverse flow elution, to the stabilized colorimetric method, and to the finer resin particles. The reverse flow pattern eliminates inaccurate results caused by erratic  $P_2O_5$  recovery found with the downflow gradient elution, shown in Fig. 5. In addition, the flow pattern and finer resin give a sharper separation of the phosphate species, thus reducing the possibility of cross-contamination between fractions.

In Figs. 4 and 6, it can be seen that the separation of species is improved by

the order of 50 per cent.

The tightly packed, sealed column prevents both contamination and disturbance of the resin bed. The supplementary pressure regulator (17) facilitates maintenance of the high flow rate. The large sample size makes it possible to use conventional, macro methods (16) in determining the  $P_2O_5$  content of the STP fraction, if so desired.

## Acknowledgments:

The author is indebted to C. H. Russell for his continued support and encouragement, and to C. F. Callis, E. Karl-Kroupa, J. S. Metcalf, and R. C. Manning for their helpful suggestions and continued interest.

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# Random Samples...

## FROM THE CURRENT MATERIALS NEWS

### Helium

THE DEMAND for helium, second-lightest known gas, is rapidly exceeding supply. Once used mainly in balloons and dirigibles, it has become valuable in both research and industry in low-temperature research, missile development, and nuclear power reactors, as well as in its major industrial use—helium arc welding.

**Production facilities.**—Up to now, helium production has been a government monopoly; four recovery plants operated by the Bureau of Mines now turn out 360 million cu ft annually. A fifth plant costing \$12 million is expected to increase capacity to over 610 million cu ft yearly—over seven times the requirement in 1950. But even these amounts are not enough to meet projected demands, and the Government hopes that proposed legislation will encourage private industry to build at least twelve more recovery plants between 1965 and 1980. Ninety-nine per cent of the Free World's helium is extracted from natural gas deposits located within 250 miles of Amarillo, Tex. Finding another large, rich source in the U. S. is not probable, but elimination of present waste could increase the supply enormously. More than 4 billion cu ft are wasted annually in homes and industries using natural gas which contains recoverable quantities of helium.

**Discovery in the sun.**—In 1868 helium was discovered in the sun and was later found to exist in certain minerals as well as in natural gas. The first helium produced in quantity was ready for shipment to France just at the end of the First World War.

**Uses in research.**—Helium plays a major role in low-temperature research. At liquid-helium temperatures (under 4.2 K) certain metals become perfect conductors of small electric currents. This property of superconductivity is now being investigated for use in computer applications and in microwave amplifiers to be used in conjunction with radar and other equipment. Liquid-helium temperatures are also used to "freeze" radicals—chemical fragments that normally occur in molecular form and have a very short lifetime; research in this area may produce, among other things, a new kind of rocket propellant.

Atomic research laboratories use

helium for a number of purposes. Since it is not made radioactive when it passes through a nuclear reactor, helium is uniquely able to cool targets within reactors, allowing scientists to investigate the effects of radiation on various substances. Several AEC contractors are exploring the use of helium as a heat transfer fluid to link a nuclear power reactor with a turbine to generate usable power.

**Industrial applications.**—The major industrial application for helium is in "shielded arc" welding where the gas is used because it is extremely inert. Certain metals such as stainless steel, magnesium, copper, and aluminum cannot be welded in the presence of air because they are oxidized; an inert atmosphere of helium, however, preserves the purity of the molten metals. Helium is also used in producing the silicon and germanium crystals used in transistors.

Conventionally, helium is extracted from natural gas by a cooling process which liquefies all the other gases. New methods of extraction leading to greater purity are now being investigated.

**Better transportation.**—Better means of distribution will increase the availability of helium. Large-scale liquefaction, which permits transporting large quantities of oxygen and nitrogen for industrial purposes, is expected soon. Improvements in liquid-helium tank cars for highway or railroad will reduce the price to an estimated  $\frac{1}{3}$  to  $\frac{1}{2}$  the present cost of shipping in high-pressure cylinders.

Industrial Bulletin  
Arthur D. Little, Inc.  
November, 1958

### Cobalt—Subject of New Journal

WITH THE INCREASED use of cobalt in many phases of industry, engineers and scientists alike should be interested in the new illustrated quarterly review *Cobalt*. In the decade from 1946 to 1956 world production of cobalt has increased from about 4000 to nearly 15,000 metric tons. First used in 1910 as an alloying ingredient in high-speed steel, cobalt today has widespread uses which vary from "superalloys" used in high temperatures to cobalt salts used in the treatment of anemia.

This journal (published both in English and French) will present articles of general interest, technical articles on the varied uses of cobalt and its alloys, reports on cobalt, and news items of interest to cobalt users.

The first issue of *Cobalt* features technical articles on "The Uses of Cobalt" and "High-Temperature Alloys." "The Uses of Cobalt" includes information on world production and U. S. consumption, a historical survey of early uses, numerous cobalt alloys, uses of cobalt compounds, radioactive cobalt, electroplated cobalt, and cobalt in biochemical sciences. "High-Temperature Alloys" present applications and compositions of heat-resistant alloys, properties of superalloys, and future prospects. A section containing 68 abstracts from the current technical literature is also included.

Interested persons may obtain this issue by addressing requests on company letterhead to the Cobalt Information Center, c/o Battelle Memorial Inst., 505 King Ave., Columbus 1, Ohio. Requests outside the Americas should be directed to Centre d'Information du Cobalt, 35 rue des Colonies, Brussels, Belgium.

### New Booklet On Abrasive Wear

THREE GENERAL types of abrasive wear—gouging, grinding, and scratching—are fully explained in a new 36-page booklet, *The Role of Molybdenum in Abrasion-Resistant Materials*. The reader is told how to select the proper material for each particular type and condition of wear. For example, 12-2 alloy is recommended for resistance to gouging and impact (as in crusher liners); chromium-molybdenum steels for resistance to grinding (as in grinding balls); 15-3 alloy for resistance to scratching (as in sand-pump impellers); and 3-2-1 alloy for general-purpose abrasion resistance (as in end liners).

An extensive section tells how to produce abrasion-resistant parts with the four alloys. Numerous photographs show end uses of the materials, and mechanical property data are presented.

Copies of the new booklet are available upon request, from Climax Molybdenum Co., 500 Fifth Ave., New York 36, N. Y.



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Beyond the shadow of an illusion, this film is *sharper* than its predecessors. *Sharpness* differs from contrast and from resolving power. It represents ability to render a boundary—within how few microns the color on the transparency can change from (let us say) a certain yellow to a certain orange. This ability does not readily lend itself to quantitative statement.

We mention yellow and orange advisedly. A classic challenge to any color photographic process has been to distinguish between the hue of lemons and oranges in one bowl of fruit. The new film meets it handily. Greens are better, too.

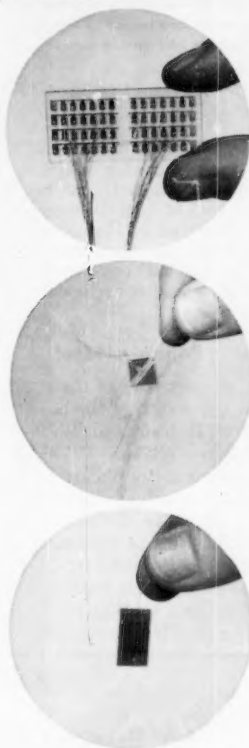
More valuable to some users will be the fidelity of the new film to the visual appearance of phenomena that the metallurgist has trained his eye to see. The metallographer now gets not only an enhancement of the fine color discrimination for which *Ektachrome* was notable even before but a new advantage in speed. Exposure Index is 32 for the *Type B* (which requires only heat-absorbing and possibly U-V filters in the usual photomicrographic setups) and 50 for the *Daylight Type* (used with electronic flash). Statistics show that in 1/25 second you get only 20% of the vibration contained in 1/5 second.

Kodak dealers now stock the new Kodak Ektachrome Film (Process E-3) in the usual sheet-film sizes. For 120 and 620 roll-film cameras it's called Kodak Ektachrome Professional Film, Daylight Type (Process E-3). They also carry various-sized kits of the new processing chemicals that Process E-3 requires. The processing cycle takes about an hour.

If a) you want paper prints and duplicate transparencies, and if b) you want to be able to manipulate your color balance toward a conception of reality transcending what can be built into inanimate film, and if c) you are willing to process both a negative and a positive before you judge your results, don't even bother with this new stuff. Stick to Kodak Ektacolor Film and Paper.

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### They transduce



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### The Brazilian trick

There was this pair of Brazilians, and they had an idea. They knew that chloranilic acid (which we sell as 2,5-Dichloro-3,6-dihydroxy-p-benzoquinone, Eastman 4539) has a vivid reddish-purple ion. But its silver salt is colorless and not very soluble. Silver chloranilate, however, is not nearly so insoluble as silver chloride.

This is where the Brazilians got their idea. Add silver chloranilate to a solution containing chloride ions and the latter will steal all the silver. Releasing free chloranilate ions! Which are reddish-purple! And easy to measure colorimetrically!

Being proper scientists, the Brazilians published their idea. A fad started. Other analytical chemists took to preparing other chloranilate salts with which to work the Brazilian trick on other hard-to-measure colorless ions. Convenience, sensitivity, and less interference resulted.

When the clan gathered at last year's Pittsburgh Conference on Analytical Chemistry, conversations on the chloranilate method were easy to start. In the interests of barium chloranilate (Eastman 7508, for sulfate) and mercury chloranilate (Eastman 7504, for chloride), we had an animated one going at our booth. Someone mentioned fluoride ion. All present agreed that for fluoride you'd want strontium chloranilate—all except one chap. Everybody knows, he maintained, that for immobilizing fluoride ions the rare earth lanthanum is tops. At having overlooked such an apparently obvious fact of nature, we were forced to conceal our embarrassment. In our fluster we failed to note the name on his badge before losing sight of him in the crowd.

This account explains the circumstances of our entry into the field of rare earth organic compounds with the offering of 2,5-Dichloro-3,6-dihydroxy-p-benzoquinone Lanthanum Salt as Eastman 7629 at \$2 for 5 grams. An abstract describing its use in fluoride determination is at present NOT available. Somebody has to write and publish before we can abstract. If you want the salt anyhow (or any of some 3700 Eastman Organic Chemicals in our latest catalog, List No. 41) you order from Distillation Products Industries, Eastman Organic Chemicals Department, Rochester 3, N. Y. (Division of Eastman Kodak Company).

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ASTM BULLETIN

## Bookshelf

Books reviewed here are furnished by publishers knowing of the broad interests of ASTM. Occasionally reviews are prepared by ASTM Staff members, but in most cases, the books are reviewed by Society members or other individuals who are well informed on the subject at hand. Members who wish to be considered for reviewing books are invited to send in their names and the subjects in which they are interested. Due to customs and mailing considerations, requests from the United States only can be considered.

Copies of these books are not available through ASTM; all inquiries concerning them should be addressed to the publisher.

### Nuclear Engineering Handbook

Edited by Harold Etherington; McGraw-Hill Book Co., Inc.; 1857 pp.; 706 illus.; 552 tables; \$25.

PREPARED BY A staff of 70 specialists, this handbook provides comprehensive coverage of nuclear theory and nuclear engineering principles and techniques in the same manner as other standard engineering handbooks.

The handbook presents four major categories of information: basic data used in nuclear engineering (particularly reactor engineering), formulas and methods of calculations used in the design of reactors as well as in other phases of nuclear engineering, the present state of the technology, and condensed descriptive reviews of nuclear theory and engineering principles.

Experts in the fields of nuclear science and engineering contributed the sections on their particular specialties. The ma-

terial is presented at a practical level for engineers interested in industrial and other uses of nuclear energy. Under the editorship of Harold Etherington, the book has been developed to strike a balance between a strict compilation of data and a cyclopedia of nuclear engineering.

### Slumbering Editors—Wake!

In the January issue of the BULLETIN credit for the review of the book, "The Analysis of Rubber and Rubber-Like Polymers" by William C. Wake was erroneously given to Willard C. Wake. The review was actually written by W. P. Tyler, chairman, Subcommittee on Chemical Analysis of Committee D-11 on Rubber and Rubber-Like Materials. Our apologies to the author, the reviewer, and also to Willard C. Wake, whoever he may be.

### Professional Income of Engineers—1958

Engineers Joint Council, 29 West 39th St., New York 18, N. Y.; \$3.00.

THIS SURVEY is the result of the third study of professional income of engineers by the Engineers Joint Council. The previous survey covered the interval from 1953 to 1956. In 1953 the over-all median annual salary for all graduates was \$6500, in 1956 \$7750, and in 1958 \$8750. These increases are not evenly distributed among various classifications or experience levels, however, and the report goes on to show the breakdown of these figures. Salaries of engineers employed by federal, state, and local governments remain below those in industry, although the gap noted in 1956 has been narrowed. The largest gap in salary is among engineers with twelve or more years of experience. The report contains 41 tables and figures which cover varying educational levels, all levels of government, teachers, engineering societies, and magazine staffs. Included in the survey were 190,810 engineering graduates: 155,124 from industry (546 companies), 30,028 from government (131 agencies), and 5658 in the field of education. This report is probably the most comprehensive one of its kind ever made in the United States.

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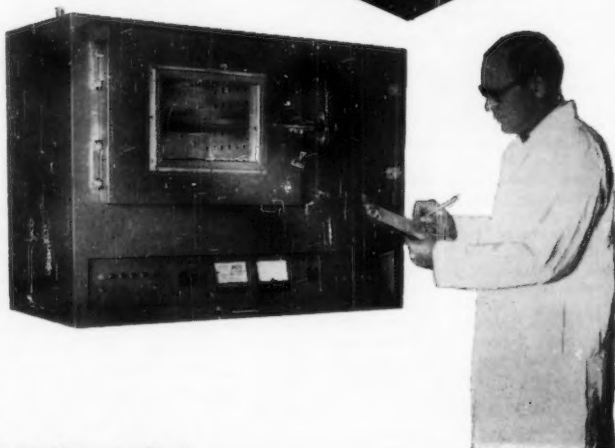
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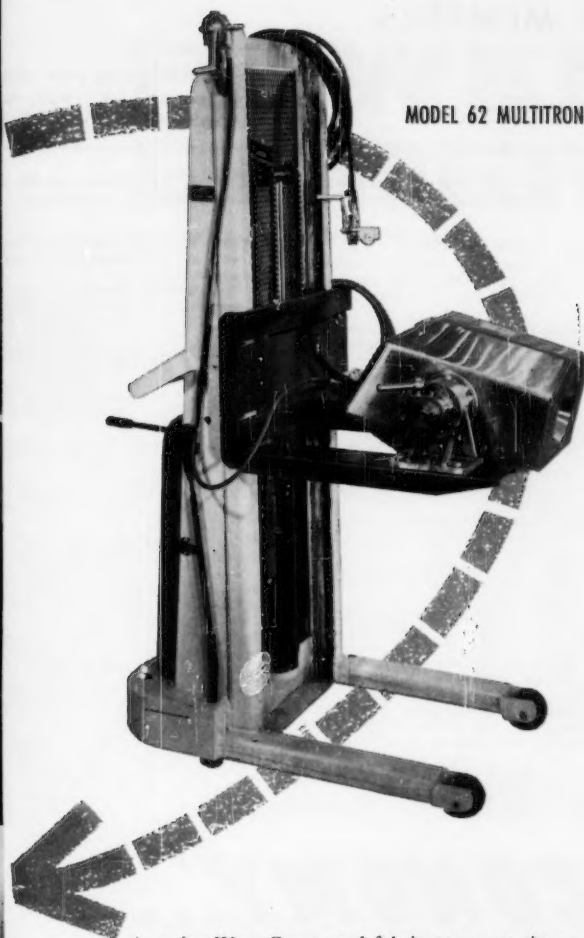
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Note—Names are arranged alphabetically—Company members first then individuals—  
Your ASTM Year Book shows the areas covered by the respective Districts

### Central New York District

**Hansen, L. A.**, technical director, Coated Abrasive Div., Behr-Manning Co., A Division of Norton Co., Box 808, Troy, N. Y.  
**Venditti, David John**, draftsman, special investigator, Link Aviation, Inc., Binghamton, N. Y. For mail: 29 Roosevelt Ave., Endicott, N. Y. [A]\*

### Chicago District

**Mayer and Co., Oscar, A. Ellrodt**, general purchasing agent, 910 Mayer Ave., Madison, Wis.  
**Testworth Laboratories, Inc.**, S. W. Campbell, president, Commercial Rd. and Westgate, Addison, Ill.  
**Antrim, John D.**, teaching and research, School of Civil Engineering, Purdue University, Lafayette, Ind. [A]  
**Ayers, George W.**, section supervisor, Organic Research, Pure Oil Research Center, Crystal Lake, Ill.  
**Babcock, J. T. W.**, managing director, Metal Roof Deck Technical Inst., 53 W. Jackson Blvd., Chicago 4, Ill.  
**Barlow, Bertram L.**, laboratory manager, Warner Electric Brake and Clutch Co., Beloit, Wis.  
**Brown, Kenneth M.**, manager, Treating Dept., Universal Oil Products Co., 30 Algonquin Rd., Des Plaines, Ill.

\* [A] denotes Associate Member.  
† [S] denotes Sustaining Member.

**Buntain, E. T.**, drafting supervisor, R-B-M Controls Div., Essex Wire Corp., Logansport, Ind.

**Clouser, William Sands**, assistant professor, University of Wisconsin, Madison, Wis. For mail: 27-B University Houses, Madison 5, Wis.

**Costin, Robert**, experimental engineer, Boston Corp., 133 W. Oregon St., Milwaukee 4, Wis.

**Cramer, K. L.**, chief metallurgist, The Oliver Corp., Plant 1, 533 Chapin, South Bend, Ind.

**Doremus, George E., Jr.**, technical supervisor, American Brass Co., 1420 Sixty-third St., Kenosha, Wis.

**Griffith, B. W.**, Structural Engineering Dept., Howard R. Green Co., Bever Bldg., Cedar Rapids, Iowa.

**Gwinnup, Donald M.**, city engineer, City of Anderson, City Hall, Anderson, Ind. For mail: 126 E. Eighth St., Anderson, Ind.

**Horak, F. V.**, manager, Metallurgical Operations, Harnischfeger Corp., 4400 W. National Ave., Milwaukee 14, Wis.

**Johnson, Robert N.**, assistant chief industrial engineer, Elgin, Joliet & Eastern Railway Co., Maple Rd., Joliet, Ill.

**Moore, Fred S.**, works manager, James Manufacturing Co., 104 W. Milwaukee St., Fort Atkinson, Wis.

**Morykwas, Steve**, superintendent, Chemical and Metallurgical Labs., Curtiss-Wright Corp., South Bend Div., 701 W. Chippewa Ave., South Bend, Ind.

**Olin, Stephen M.**, secretary-treasurer, Mansfield Laboratories, Inc., 419 Monger Bldg., Elkhart, Ind.

**Putnam, A. H.**, A. H. Putnam Co., 2109½ Fourth Ave., Rock Island, Ill.

**Schwartz, Frederick W., Jr.**, chief engineer, Union Tank Car Co., 228 N. LaSalle St., Chicago 1, Ill.

**Shaw, George W.**, sales engineer, Baldwin-Lima-Hamilton Corp., 627 Railway Exchange, Chicago, Ill. For mail: 7445 N. Sheridan Rd., Chicago 26, Ill. [A]

**Smith, A. E.**, chief engineer, Chicago Great Western Railway Co., Oelwein, Iowa.

**Smith, John Edward**, engineering trainee, Inland Steel Co., East Chicago, Ind. For mail: 1700 McKinley St., Gary, Ind. [A]

**Thompson, P. G.**, Quality Control, General Controls Co., Michigan Div., Iron Mountain, Mich.

**Wreath, A. Rodger**, supervisor, Quality Control, Victor Chemical Works, Eleventh and Arnold Sts., Chicago Heights, Ill.

### Cleveland District

**Dillon, Gordon P.**, division manager of quality control, Continental Can Co., Inc., Flexible Packaging Div., Mount Vernon, Ohio.

**Jackson, Rex L.**, test engineer, Firestone Steel Products Co., Box 2785, Akron 1, Ohio.

**Joubin, J. Charles**, chief laboratory engineer, Line Material Industries, Box 510, Zanesville, Ohio.

**McKeon, Richard D.**, assistant treasurer and engineer, The Masters & Mullen Construction Co., 437 Chester 12th Bldg., 1120 Chester Ave., Cleveland 14, Ohio.

**Rogers, Edwin J.**, general manager, Diamondite Products Manufacturing Co., Shreve, Ohio.

**Rogers, Glenn J.**, 187 Buffington, Akron 13, Ohio. [A]

**Showman, Robert L.**, product engineer, Porcelain Products Co., 225 N. Patterson, Carey, Ohio.

(Continued on page 90)

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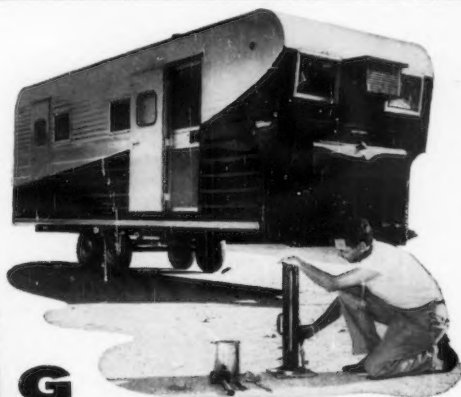


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(Continued from page 88)

**Spriggs, Richard M.**, senior research engineer, Ferro Corp., 4150 E. Fifty-sixth St., Cleveland, Ohio. For mail: 9146 Briarwood Rd., Northfield, Ohio. [A]  
**Sprulis, George M.**, director of research, Tyrex, Inc., 350 Fifth Ave., New York 1, N. Y. For mail: First National Tower Bldg., Main and Mill Sts., Akron 8, Ohio.

### Detroit District

**Bell, Leonard W.**, office engineer, Portland Cement Assn., 2108 Michigan National Tower, Lansing, Mich. For mail: 1402 Fisher Bldg., Detroit 2, Mich. [A]  
**DeBoe, H. M.**, mechanical engineer, Emery, Marker & Campbell, 1408 Toledo Trust Bldg., Toledo 4, Ohio.  
**Gammell, Neal**, director, Research and Development, Freuhauf Trailer Co., 10940 Harper, Detroit, Mich.

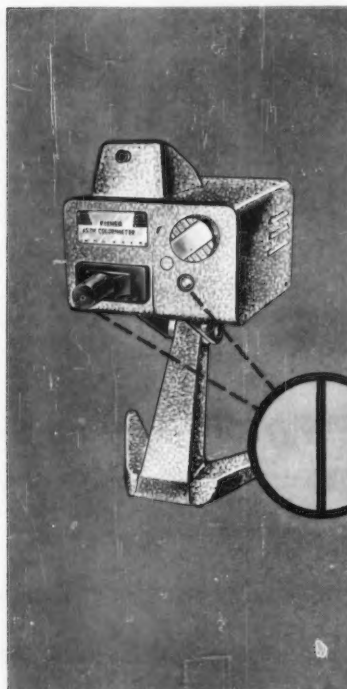
**Leland, Robert D.**, instructor, Wayne State University, Detroit, Mich. For mail: 118 Cambridge, Pleasant Ridge, Mich. [A]

### New England District

**Boston Woven Hose and Rubber Co.**, N. J. Cyphers, Box 1071, Boston 3, Mass.  
**Buck, Henry Wolcott**, owner, Buck & Buck, 650 Main St., Hartford 3, Conn.  
**Donovan, D. R.**, sales manager, North American Phillips Co., Inc., Elmet Div., Lisbon Rd., Lewiston, Me.  
**Goldman, Alfred Y.**, product engineer, Ansonia Mills, Inc., East Taunton, Mass.  
**Hamilton, Robert J.**, chief engineer, Socony Mobil Oil Co., Inc., 648 Beacon St., Boston 15, Mass.  
**Kuhn, Donald E.**, research engineer, Research and Development Lab., The Chapman Valve Manufacturing Co., Indian Orchard, Mass.  
**McKnight, George S., Jr.**, director of research, Oxford Paper Co., Rumford, Me.

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**Commonwealth Services, Inc.**, J. G. Shanley, general purchasing agent, 300 Park Ave., New York 22, N. Y.  
**Burger, Elting G., Jr.**, structural engineer, Charles J. Cooke, Architect, 20 Cannon St., Poughkeepsie, N. Y. [A]  
**Carlson, Eugene E.**, sales engineer, A. Johnson and Co., Inc., 21 West St., New York 6, N. Y.  
**Cooper, Nathan E.**, special representative, Aluminum and Chemical Corp., 168 Mason St., Greenwich, Conn. For mail: 61 Broadway, New Haven 11, Conn.  
**Cranston, William M.**, quality control manager, Western Printing and Lithographing Co., North Rd., Poughkeepsie, N. Y.  
**Dudley, Ralph H.**, special research and development officer, U. S. Department of the Air Force, Special Structures Div., Special Weapons Center, Kirtland Air Force Base, Albuquerque, N. Mex. For mail: 900 W. 190th St., New York 40, N. Y. [A]  
**Gloger, Walter A.**, assistant technical director, National Lead Co., Research Lab., 150 York St., Brooklyn 1, N. Y. (Effective 1958).  
**Herenchak, Alexander**, project engineer, Barnett & Herenchak, 30 Clinton St., Newark 2, N. J.  
**Ingram, J. W.**, technical director, Ansbacher-Siegle Corp., 92 Chestnut Ave., Rosebank, Staten Island 5, N. Y.  
**Konviser, David D.**, metallurgist, International Testing Laboratories, Inc., 580 Market St., Newark, N. J. For mail: 358 Mt. Prospect Ave., Newark 4, N. J.  
**Kuran, Patricia M.**, librarian, Radio Corporation of America, Semiconductor and Materials Div., Rt. 202, Somerville, N. J.  
**Lulla, Jack D.**, research director, Technical Tape Corp., W. 177th St. and Harlem River, Bronx 53, N. Y. For mail: 1304A Midland Ave., Yonkers, N. Y.  
**Meskill, Robert E.**, technical coordinator, Esso Standard Oil Co., 15 W. Fifty-first St., New York 19, N. Y.  
**Moran, John J., Jr.**, metallurgist, The International Nickel Co., Inc., 67 Wall St., New York 5, N. Y.  
**Nycum, R. S.**, manager of sales, Titanium Metals Corporation of America, 233 Broadway, New York 7, N. Y.  
**Oldham, W. N.**, technical director, American Cyanamid Co., Plastics and Resins Div., Wallingford Lab., Wallingford, Conn.  
**Owades, Joseph L.**, director of laboratories, Schwarz Laboratories, Inc., 230 Washington St., Mount Vernon, N. Y.  
**Peskin, William L.**, manager, Product Engineering, Carborundum Co., Refractories Div., Perth Amboy, N. J.  
**Poliakoff, Melvin Z.**, technical director, The Penetona Co., 74 Hudson Ave., Tenafly, N. J.  
**Reifenbe, Walter**, chemical engineer, U. S. Army Chemical Center, Edgewood, Md. For mail: 101 Eightieth Rd., Kew Gardens 15, N. Y. [A]  
**Thomas, Jerome Joseph**, assistant civil engineer, Construction Div., New York State Department of Public Works, Dutchess Turnpike, Poughkeepsie, N. Y. For mail: 19 Peter Cooper Dr., Poughkeepsie, N. Y. [A]  
**Wheeler, H. K.**, director of technical service, American Oil Co., 555 Fifth Ave., New York 17, N. Y.  
**Wilson, F. S.**, laboratory supervisor, Socony Paint Products Co., Metuchen, N. J.  
**Zuckerman, Joseph L.**, research chemist, Disogrin Industries, 510 S. Fulton Ave., Mt. Vernon, N. Y. [A]



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- Byrne, John J.**, field engineer, Pacific Gas and Electric Co., 245 Market St., San Francisco 6, Calif. For mail: Box 2568, Haas Power House, Fresno, Calif. [A]
- Campbell, John D.**, project engineer in charge of environmental test lab., Philco Corp., Western Development Labs., 3875 Fabian Way, Palo Alto, Calif.
- Dawson, P. B., Jr.**, chief engineer, Pelton Div., Baldwin-Lima-Hamilton Corp., 2929 Nineteenth St., San Francisco 10, Calif.
- Dockey, Merritt E., Jr.**, materials and processes engineer, General Electric Co., 5441 E. Fourteenth St., Oakland 1, Calif.
- Garrison, William A.**, materials testing engineer, Contra Costa County, Public Works Dept., Box 509, Martinez, Calif. For mail: 449 Marshall Dr., Walnut Creek, Calif.
- Iwao, Kumiy Roy**, design engineer, Aerojet-General Nucleonics, Box 77, San Ramon, Calif. For mail: 3669 Boyer Circle, Lafayette, Calif. [A]
- Meyer, Victor William**, junior civil engineer, Robert M. Snyder and Associates, Box 873, Stockton, Calif. For mail: 901 Dainty Ave., Brentwood, Calif. [A]
- Morgan, Albert R., Jr.**, process superintendent, Westvaco Mineral Products Div., Food Machinery and Chemical Corp., Newark, Calif.

### Ohio Valley District

- Thermometer Corporation of America**, John L. Hobin, director of development and research, Box 58, Springfield, Ohio.
- Bexley Board of Education**, R. E. Kessler, clerk-treasurer, 326 S. Cassingham Rd., Columbus 9, Ohio.
- Creevy, Joseph A.**, assistant to vice-president, Acme-Newport Steel Co., Newport, Ky.
- Ellwell, Jeffery B.**, manufacturing engineer, Westinghouse Electric Corp., Lima, Ohio. [A]
- Fryman, D. C.**, chemist, Monarch Marking System Co., 216 S. Torrence St., Dayton 3, Ohio.
- Gaither, C. Gordon**, partner, Howard K. Bell, Consulting Engineers, 553 S. Limestone St., Lexington, Ky.
- Koch, Robert F.**, engineer, Supermet Div., Globe Industries, Inc., 1460 Cincinnati St., Dayton 8, Ohio.
- LeBlanc, W. J.**, manager, Research and Development Engineering Dept., The B. F. Goodrich Co., Peters Rd., Box 511, Troy, Ohio.
- Thompson, Paul F.**, senior chemist, Carlisle Chemical Works, Inc., Reading 15, Ohio.

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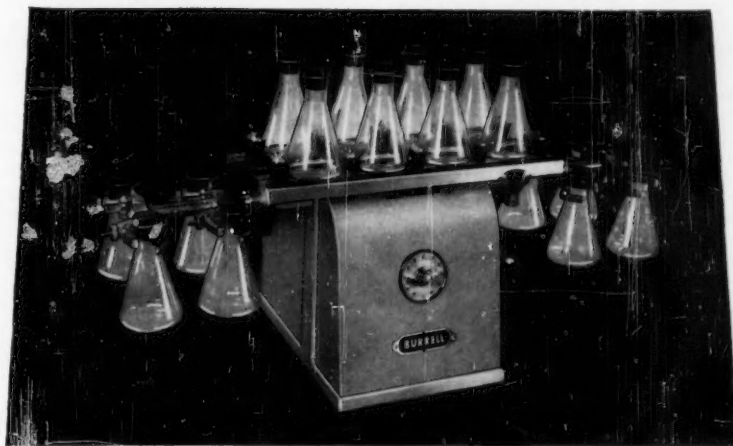
- Lavino and Co., E. J., H. A. Heilgman**, general manager, Technical Dept., Box 29, Norristown, Pa.
- Standard Pressed Steel Co.**, Robert L. Sproat, chief metallurgist, Highland Ave., Jenkintown, Pa.
- Cohen, Lester S.**, director, Organic Div., Wyandell Laboratories, 1355 N. Front St., Philadelphia 22, Pa.
- Grabois, Norman**, textile chemist, Industrial Ry-Products and Research Co., 2204 Walnut St., Philadelphia 3, Pa.
- Griffin, D. F.**, chief metallurgist, Landis Machine Co., Waynesboro, Pa.
- Grottger, Miro A.**, director, Research and Development, Precision Tube Co., North Wales, Pa.
- Kling, Vincent G.**, principal architect, Vincent G. Kling, A. I. A., 917 Corinthian Ave., Philadelphia 30, Pa.
- Krecker, Bruce D.**, vice-president, Andrew S. McCreath and Son, Inc., 236 Liberty St., Harrisburg, Pa.
- Roth, K. G.**, standards engineer, Mack Trucks, Inc., 601 S. Tenth St., Allentown, Pa.
- Smith, Robert Loran**, engineer, Clifton Precision Products Co., Inc., Marple and Broadway, Clifton Heights, Pa. For mail: 914 Rhoads Ave., Secane, Pa.
- Weigle, Robert Edward**, research associate, Rensselaer Polytechnic Inst., Eighth Ave., Troy, N. Y. For mail: 1613 Wayne Ave., York, Pa.

(Continued on page 92)

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**Robertshaw Thermostat Div.**, Robertshaw-Fulton Controls Co., Anthony J. Chinnici, chief chemist, Youngwood, Pa.

**Ballinger, Ross A.**, director, quality surveys, United States Steel Corp., 525 William Penn Pl., Room 2420, Pittsburgh 30, Pa.

**Bowden, Raymond C., Jr.**, staff engineer, research and technology, National Tube Div., United States Steel Corp., 525 William Penn Pl., Pittsburgh 30, Pa.

**Brown, Charles H.**, manager, laboratory services, Universal-Cyclops Steel Corp., Bridgeville, Pa. For mail: 1252 Justine St., Pittsburgh 4, Pa.

**Eismont, Peter P.**, chief chemist, United States Steel Corp., Duquesne Works, Duquesne, Pa.

**Evans, John E.**, supervisor, maintenance and tooling, Small Tube Products, Inc., Box 1032, Altoona, Pa.

**Johnsen, Knut J.**, technical representative, Coal Chemical Sales Div., United States Steel Corp., 525 William Penn Pl., Room 1007, Pittsburgh 30, Pa.

**Lindfors, Hans A.**, estimator, Pittsburgh Piping and Equipment Co., 159 Fortyninth St., Pittsburgh 1, Pa. For mail: 5541 Beverly Pl., Pittsburgh 6, Pa. [A]

**Lund, Anders E.**, wood technologist, Koppers Co., Inc., Verona Research Center, Box 128, Verona, Pa.

**Mercer, Robert S.**, development chemist, Pennsalt Chemicals Corp., Natrona, Pa.

**Slavish, Peter J.**, asst. district manager, Baldwin-Lima-Hamilton Corp., Waltham 54, Mass. For mail: 1098 Union Trust Bldg., Pittsburgh 19, Pa.

**Trinkhaus, Ralph W.**, quality control engineer, Westinghouse Electric Co., P. A. D., Box 1047, Pittsburgh 30, Pa.

**Ward, Albert A., Jr.**, assistant analyst, United States Steel Corp., Commercial Research Dept., 525 William Penn Pl., Pittsburgh 30, Pa.

**Wolfe, Jerome K.**, research metallurgist, Universal-Cyclops Steel Corp., Bridgeville, Pa.

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**Eastern New Mexico University Library**, Librarian, Portales, N. Mex.

**Runyan, Damon**, consulting engineer, 6915 Lakewood Pl., Denver 15, Colo.

### St. Louis District

**Aberle, Richard H.**, Metallurgical Dept., American Brake Shoe Co., 4939 Manchester Ave., St. Louis 10, Mo. [A]

**Ackerman, George H.**, executive vice-president, Missouri Rolling Mill Corp., 6800 Manchester, St. Louis 10, Mo.

**Blair, William M.**, civil engineer, Illinois Highway Dept., Effingham, Ill. For mail: 1007 S. Park St., Effingham, Ill. [A]

**Caraffa, Anthony F.**, president, A. C. Fuel and Lubricants, Inc., 255 E. Monroe St., Kirkwood 22, Mo.

**Finley, John T.**, vice-president, chief engineer, James R. Kearney Corp., 4236 Clayton Ave., St. Louis 10, Mo.

**Grubb, Roderic**, director of laboratories, The Coleman Co., Inc., 250 N. St. Francis, Wichita 1, Kans.

**Hoffman, Adeline M.**, professor and chairman, Department of Clothing and Textiles, School of Home Economics, Southern Illinois University, Carbondale, Ill.

**Magers, A. W.**, chief chemist, Great Lakes Pipe Line Co., Kansas City 42, Mo. For mail: Box 152, Kansas City 17, Kans.

**Manley, Robert T.**, The Vendo Co., 7400 E. Twelfth St., Kansas City 26, Mo.

**Newman, W. C.**, chief draftman, Beech Aircraft Corp., 9709 E. Central, Wichita 1, Kans.

**Novak, Darwin A., Jr.**, chemical engineer, Uranium Division, Mallinckrodt Chemical Works, Box 472, St. Charles, Mo. For mail: 777 N. Fortieth St., East St. Louis, Ill. [A]

**Roberts, Bruce E.**, partner, Wilson and Co., Engineers and Architects, 631 E. Crawford, Salina, Kans. For mail: Box 28, Salina, Kans.

**Smith, Edward F.**, acting technical director, E. L. Bruce Co., Box 397, Memphis 1, Tenn.

### Southeast District

**Amis, John C., Jr.**, manager, vice-president, J. B. Ford Co., 16 Patio DeLeon, Fort Myers, Fla. For mail: Box 211, Bonita Springs, Fla.

**Bryson, James A.**, manager, metals development, Tennessee Products and Chemical Corp., 4800 Central Ave., Chattanooga 10, Tenn.

**Cooper, Frank H.**, superintendent, dyeing and finishing, Dixie Belle Mills, Inc., Calhoun, Ga.

**Genung, Donald J.**, chief metallurgist, Ross-Meehan Foundries, 1601 Carter St., Chattanooga 1, Tenn.

**Glasscock, Nell Skaggs**, associate professor, School of Home Economics, Alabama Polytechnic Inst., Auburn, Ala.

**Hurd, Lewis R.**, junior highway engineer, Georgia State Highway Dept., 2 Capital Sq., Atlanta, Ga. For mail: 1971 Main St., N. W., Atlanta 18, Ga.

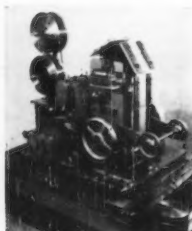
**Keilen, John J., Jr.**, director, research and development, Charleston Rubber Co., Stark Industrial Park, Charleston, S. C.

**Mansour, G. A.**, manager, Birmingham District, Pittsburgh Testing Laboratory, 900 Sixth Ave., N., Birmingham 4, Ala.

**Reid, Edward S.**, manager, Construction Products Div., Sonoco Products Co., Hartsville, S. C.

**Strobach, Joseph T.**, manager, Materiel Inspection Dept., Lockheed Aircraft Corp., Georgia Div., 86 S. Cobb Dr., Marietta, Ga.

(Continued on page 93)



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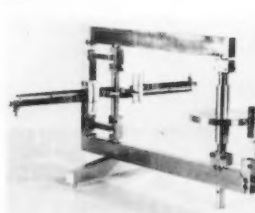
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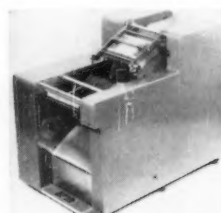
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(Continued from page 92)

**Wiley, Paul R.**, manager, Polychemicals Div., West Virginia Pulp and Paper Co., Charleston, S. C.

### Southern California District

- Austin, Dale H.**, vice-president, Golden Eagle Refining Co., Inc., 5150 Wilshire Blvd., Los Angeles 36, Calif.
- Barton, Donald T.**, associate engineer, Convair, Division of General Dynamics Corp., San Diego, Calif. For mail: 352 Broadway, Chula Vista, Calif. [A]
- Bullock, Thomas Eugene**, chief geophysicist, Dames & Moore, Geophysics Div., 2335 W. Third St., Los Angeles 57, Calif. For mail: 2908 St. George St., Los Angeles 27, Calif.
- Christen, Harvey C.**, director of quality control, Lockheed Aircraft Corp., Box 551, Factory "A," Burbank, Calif.
- Coberly, George E.**, inspector, public works, City of Los Angeles, Room 654, City Hall, Los Angeles, Calif. For mail: 7133 Beckford Ave., Reseda, Calif.
- Duncan, Bruce**, chief mechanical engineer, Amelco, Inc., 2040 Colorado Ave., Santa Monica, Calif. For mail: 24758 Malibu Rd., Malibu, Calif.
- Goodrich, J. F.**, general manager, Todd Shipyards Corp., Los Angeles Div., Box 231, San Pedro, Calif.
- Hill, Irvine A.**, chief engineer, Western Insulated Wire Co., 2425 E. Thirtieth St., Los Angeles 58, Calif.
- Joy, Austin S.**, manager, Tube and Steel Div., Brumley-Donaldson Co., 3050 E. Slauson Ave., Huntington Park, Calif.
- Luckey, Manley J.**, owner and director, Luckey Laboratories, 1295 E. St., San Bernardino, Calif.
- Showalter, Alfred J.**, chief engineer, San Gabriel Ready Mix, 965 N. Fair Oaks, Pasadena, Calif. For mail: 409 S. Gladys, San Gabriel, Calif.
- Staudhammer, John**, instructor, University of California, Los Angeles, 405 Hilgard, Los Angeles 24, Calif. For mail: 1017 El Paso Dr., Los Angeles 42, Calif. [A]
- Swanson, John W.**, manager of testing lab., Delsen Corp., 719 W. Broadway, Glendale 4, Calif.
- Wood, Guy A.**, chief cable engineer, Jefferson Electronic Products Corp., 322 State St., Santa Barbara, Calif. [A]

### Southwest District

- Cormier, A. P.**, office manager, Pittsburgh Testing Laboratory, 2128 Hodges St., Lake Charles, La.
- Goldstein, Lynn E.**, engineer, Shell Chemical Corp., Deer Park, Tex. For mail: 1907 Oakdale, Houston 4, Tex. [A]
- Gorsha, Newton J.**, manager, Ralph S. Holt Testing Laboratory, Inc., 109 Parkwood Dr., Alexandria, La.
- Kenyon, L. C., Jr.**, engineer, Analytical Section, Esso Standard Oil Co., Louisiana Div., Box 551, Baton Rouge 1, La.
- Riley, Robert R.**, chief chemist, Halliburton Portland Cement Co., Box 1200, Corpus Christi, Tex.
- Schneider, Harold**, manager, Quality Control Dept., Tuboscope Co., Inspection Div., P. O. Box 808, Houston 1, Tex.
- Shunator, Bat, Jr.**, junior engineer, Sunray Mid-Continent Oil Co., Box 2039, Tulsa, Okla. For mail: Box 461, Pauls Valley, Okla. [A]
- U. S. Department of Agriculture Library**, New Orleans Branch, Dorothy B. Skau, librarian, Box 7307, New Orleans 19, La.

### Washington, D. C., District

- Besse, N. K.**, works manager, Revere Copper and Brass, Inc., 1301 Wicomico St., Baltimore 3, Md. For mail: Box 2075, Baltimore, Md.
- Feinberg, Irving J.**, chief, physical metallurgy group, U. S. Naval Ordnance Laboratory, Bldg. 70-106, White Oak, Silver Spring, Md.
- Gladstone, John W.**, quality control supervisor, Halifax Paper Co., Inc., Roanoke Rapids, N. C. [A]
- Hair, Marion S.**, engineer, W. K. Dickson and Co., Inc., 404 1/2 S. Tryon St., Charlotte 2, N. C.

**Khawam, Antoine**, technical director, The Englander Co., Inc., Industrial Plastics, 227 N. Warwick Ave., Baltimore 23, Md.

**Quality Assurance Technical Agency**, Commanding Officer, Army Chemical Center, Md.

**Rowland, Ronald H.**, chemist, National Paint, Varnish and Lacquer Assn., 1500 Rhode Island Ave., N. W., Washington 5, D. C. For mail: 3527 T St., N. W., Washington 7, D. C. [A]

**Williams, Robert K., Jr.**, executive director, Virginia Asphalt Assn., Hotel King Carter, Richmond 19, Va.

**Woolf, Alan R.**, physicist, Division 9.6 (cements), National Bureau of Standards, Connecticut Ave. and Van Ness St., N. W., Washington 25, D. C. For mail: 5001 Massachusetts Ave., N. W., Washington 16, D. C.

### Western New York-Ontario District

- Anderson, Y. R.**, ceramic engineer and plant superintendent, Cooksville-Laprairie Brick, Ltd., Cooksville, Ont., Canada.
- Cotter, W. J.**, chief chemist, Ford Motor Company of Canada, Ltd., Oakville, Ont., Canada.
- Davis, K. J.**, general manager, International Resistance Co., Ltd., 349 Carlaw Ave., Toronto, Ont., Canada.
- Geverdt, Gerald R.**, inspector, Moog Valve Co., Inc., East Aurora, N. Y. For mail: 133 Bunting Rd., Orchard Park, N. Y. [A]
- Gramlewicz, S.**, manager of engineering, Canadian Line Materials, Ltd., Station H, Toronto 13, Canada.
- Jones, C. Frank**, works manager, English Electric Canada, A Division of John Inglis Co., Ltd., St. Catharines, Ont., Canada.
- Lindquist, Knute T.**, supervisor, Metallurgy and Welding Laboratory, General Electric Co., 2901 E. Lake Rd., Erie 1, Pa.
- Monahan, Robert E.**, purchasing agent, City of Erie, City Hall, Erie Pa.
- Pearson, John H.**, manager, E. B. Allen Inspection, Ltd., Box 115, Hamilton, Ont., Canada.

**Sear, Thomas B.**, consulting engineer, 65 Broad St., Rochester 14, N. Y.

**Stephens, William W.**, manager, technical branch, The Carborundum Metals Co., Box 32, Akron, N. Y.

**Wise, Douglas C.**, ceramic engineer, The Carborundum Co., Buffalo Ave., Niagara Falls, N. Y. For mail: 5 Irving St., Alden, N. Y. [A]

**Workman, Russell C.**, development representative, Dominion Rubber Co., Ltd., Tire Div., 149 Strange St., Kitchener, Ont., Canada.

### Outside Established Districts

**Henderson, John C.**, assistant foundry superintendent, Omaha Steel Works, 609 S. Forty-eighth St., Omaha 6, Nebr.

**Honolulu, City and County of**, Municipal Reference Library, Rachel P. Comba, municipal librarian, Municipal Bldg., Honolulu 13, Hawaii.

### Other Than U. S. Possessions

- Aceros Alfa Monterrey, S. A.**, Armando Garza, manager, Apartado 636, Monterrey, N. L., Mexico.
- Abbate, Alfonso**, assistant engineer, Development Board, Chamchamal, Iraq. [A]
- Addis Ababa, University College of**, Engineering Department, G. Cantin, head, Box 399, Addis Ababa, Ethiopia.
- Aicher, Ragna**, chief information officer, The Bowater Research and Development Co., Research Div., Northfleet, Kent, England.
- Alam, Mahboob**, Textile Department, Syed Brothers, 155-58 Liaquat Market, Bunder Rd., Karachi, Pakistan. [A]
- Ankli, Walter L.**, vice-president, Aismalibar S. A., Moncada, Barcelona, Spain. For mail: Avda. Generalísimo Franco, 600, pral., Barcelona, Spain.
- Argendel, Nicholas**, chief chemist, Ciment Quereq, Inc., St. Basille de Portneuf, P. Q., Canada.

(Continued on page 95)

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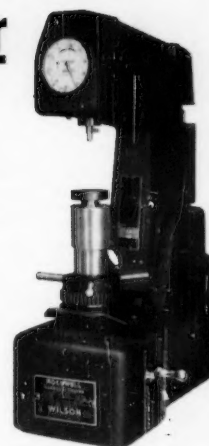
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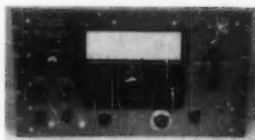
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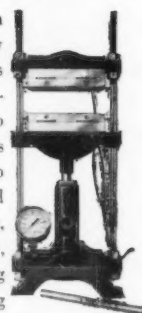
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## New Members

(Continued from page 93)

**Bernard, Jean L.**, chief, testing of materials, Commissariat a L'Energie Atomique, SACLAY, B. P. 2, Gif-Sur-Yvette (S.O.), France.

**Brink, G. F. A.**, quality control manager, Asbestos Corp., Ltd., Thetford Mines, P. Q., Canada.

**Burr, Max**, civil engineer, Cia. Electro Metalurgica S. A., Vicuna Mackenna 1550, Santiago, Chile. For mail: Casilla 3463, Santiago, Chile.

**Finch, Douglas C.**, chief metallurgist, Swindon Branch, Pressed Steel Co., Ltd., Stratton St. Margaret, Swindon, Wiltshire, England.

**Fouarge, J.**, directeur du laboratoire forestier de l'Etat, Institut Agronomique, Gembloux, Belgium.

**Hayes, John H.**, materials engineer, Ammann & Whitney-Husted, Box 1423, Teheran, Iran.

**Hollander, Bert**, technical manager, Cimayex Com. E Ind. S. R. L., Avda. de Mayo 1370, 4° piso, Buenos Aires, Argentina. For mail: c/o Federico Lacroze, 2363, 8° piso Dto. 20, Buenos Aires, Argentina.

**Ishihara, Yasumasa**, vice-manager, production engineering dept., Toyota Motor Co., Ltd., Toyoda-Shi, Aichi-ken, Japan.

**Kurpershoek, E.**, director, United States Oil Co., 61, Jullilestraat, Rotterdam 7, The Netherlands. For mail: 214 Molenaan, Rotterdam 13, The Netherlands.

**Laboratoire National D'Essais**, Maurice Bellier, director, 1, Rue Gaston Boissier, Paris (15e), France.

**MacKenzie, John D.**, general manager, Chemical Concrete Products of Canada, Ltd., Wellington, Ont., Canada.

**Pitkethly, T. E.**, BP Trading, Ltd., Britannic House, Finsbury Circus, London, E. C. 2, England.

**Pryer, Robert W. J.**, soils engineer, Quebec, North Shore and Labrador Railway, Sept Iles, P. Q., Canada.

**Puerto Rico Aqueduct and Sewer Authority**, Rafael V. Urrutia, executive director, Box 7066, Barrio Obrero Station, San Juan, Puerto Rico.

**Salesse, Marc**, chief, Metallurgy and Applied Chemistry Dept., Commissariat a L'Energie Atomique, Centre d'Etudes Nucleares de Saclay, B. P. 2, Gif-Sur-Yvette (S. O.) France.

**Schiller, H.**, technical director, Industria Venezolana de Cables Electricos C. A., Apartado 173, Valencia, Venezuela.

**Skerrett, N. P.**, Oil Products Development Dept., The Shell Petroleum Co., Ltd., St. Helens Court, Great St. Helens, London, E. C. 3, England. For mail: 16, Finsbury Circus, London, E. C. 2, England.

**Todkill, P. J.**, senior scientific officer, Mines Branch, Canada Department of Mines and Technical Surveys, Ottawa, Ont., Canada.

**Torchinsky, B. B.**, consulting engineer, B. B. Torchinsky and Associates, Ltd., 1002 Central Ave., Saskatoon, Sask., Canada.

**Western Australia Public Works Department**, The Librarian, Stationery Store, Perth, Western Australia.

**Zajac, Jaroslav**, production chemist, Cia. Shell de Venezuela, Laboratorio Produccion, Maracaibo, Venezuela.

**Zea, Luis Fernando**, project engineer, INER GAS, Apartado 6721, Caracas, Venezuela. [A]

## OTS Research Reports

THESE REPORTS, recently made available to the public, can be obtained from the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. Order by number.

*Structural Evaluation of Beryllium Produced by Several Processes*, PB 151263, \$2.

*Technology of Molybdenum and Its Alloys*, PB 131793, 75 cents.

*Research on Ferrous Materials Fatigue*, PB 151243, \$2.50.

*Effect of Static Prestrain on the Pro-Fatigue Properties of Unnotched and Notched Materials (4 Aluminum Alloys) at Room and Elevated Temperature*, PB 151280, \$1.75.

*Development of Brazed Sandwich Construction Materials for High-Temperature Applications*, PB 151272, \$2.50.

*Special Welding Techniques*, MND-1045, \$2.25.

*Stress-Strain-Temperature-Time Relationships for Refractory Materials*, NAA-SR-3205, \$1.25.

*Ultrasonic Welding of Structural Aluminum Alloys*, PB 131680, \$2.25.

*Development of Filler Wire for Welding Army Ordnance Armor by the Inert-Gas-Shielded Consumable-Electrode Process*, PB 131689, \$1.

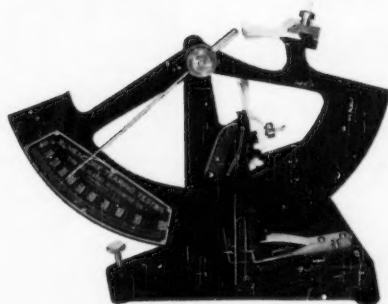
*Pilot Production, Fabrication and Evaluation of Promising Titanium Alloys*, PB 131978, \$1.25.

*Development of a Weldable Titanium-Base Alloy of Medium Strength*, PB 151214, \$1.

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## NEWS OF MEMBERS . . .

News items concerning the activities of our members will be welcomed for inclusion in this column.

Several ASTM members were honored at the 55th Annual Convention of the American Concrete Institute in Los Angeles. **Lewis M. Tuthill**, concrete engineer, California State Dept. of Water Resources, Sacramento, Calif., was elected vice-president for a two-year term. **George C. Ernst**, professor of Civil Engineering, University of Nebraska, Lincoln, Nebr., and **Walter J. McCoy**, director of research, Lehigh Portland Cement Co., Allentown, Pa., were elected directors for three-year terms. **Herbert J. Gilkey** (honorary member of ASTM), professor, Dept. of Theoretical and Applied Mechanics, Iowa State College, Ames, Iowa, was elected to Honorary Membership. **Douglas E. Parsons**, chief, Building Technology Div., National Bureau of Standards, Washington, D. C., was awarded the Turner Medal in "recognition of notable achievement in the execution and direction of research on concrete and in furtherance of preparation and acceptance of concrete construction standards." **Frederic T. Mavis**, dean, College of Engineering, University of Maryland, College Park, Md., co-author with M. J. Greaves of the paper "Destructive Impulse Loading of Reinforced Concrete Beams" received the Wason Medal for Research.

Two ASTM members were among those who received 1959 awards from the American Chemical Society. **H. Howard Cary**, president, Applied Physics Corp., was the recipient of the Beckman Award in Chemical Instrumentation, and **James I. Hoffman**, chief of metallurgy division, National Bureau of Standards, received the Fisher Award in Analytical Chemistry.

The American Foundrymen's Society at its 63rd Casting Congress in Chicago presented three awards, two of the recipients being ASTM members. **John A. Rassenfoss**, manager, Manufacturing Research Laboratory, American Steel Foundries, East Chicago, Ind., received the Peter L. Simpson Gold Medal, and **Fred J. Walls**, vice-president, research and development, Engineering Castings, Inc., Marshall, Mich., and formerly in charge of Detroit Technical Section, Development and Research Div., The International Nickel Co., Detroit, received the John A. Penton Gold Medal.

Among the newly elected officers of the American Association for Textile Technology are the following ASTM members: **C. A. Baker**, U. S. Testing Co., Inc., Hoboken, N. J., president; **Giles Hopkins**, Rayon and Acetate Fiber Products Group,

New York, N. Y., second vice-president; and **Genevieve Smith**, Sears Roebuck & Co., New York, N. Y., to the board of governors.

**C. Howard Adams**, manager, Plastic Product Development, Monsanto Chemical Co., St. Louis, Mo., was elected secretary, Rubber & Plastics Division of The American Society of Mechanical Engineers. Mr. Adams is actively engaged in the work of ASTM Committee D-20 on Plastics.

**John B. Alexander**, formerly chemical engineer, Southwestern Portland Cement Co., Los Angeles, Calif., has been elected vice-president and chemical director.

**Victor E. Amspacher**, chief chemist, The Pennsylvania Railroad Co., Altoona, Pa., retired March 1, 1959. Mr. Amspacher joined the Society in 1951, and is active in committee work. He has served on Committees B-2 on Non-Ferrous Metals and Alloys, D-1 on Paint, Varnish, Lacquer and Related Products, D-5 on Coal and Coke, D-11 on Rubber and Rubber-Like Materials, E-3 on Chemical Analysis of Metals, D-22 on Methods of Atmospheric Sampling and Analysis, and D-26 on Halogenated Organic Solvents, of which committee he will continue to act as chairman.

**William D. Appel**, a long-time member of the Society, retired from the National Bureau of Standards, Washington, D. C., on January 9, 1959, after 36 years of service. Mr. Appel is now serving as editor of the American Association of Textile

(Continued on page 99)

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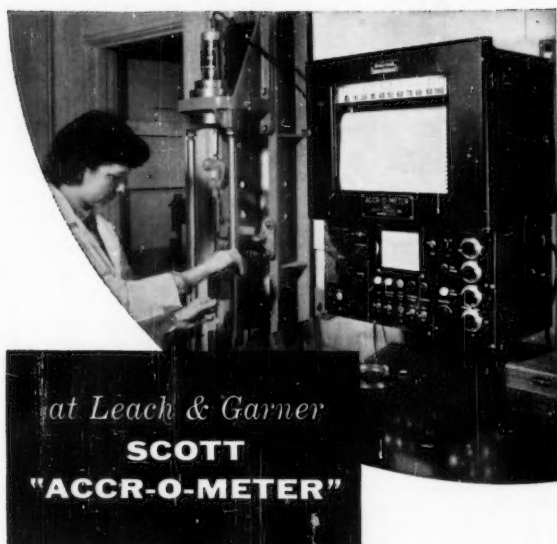
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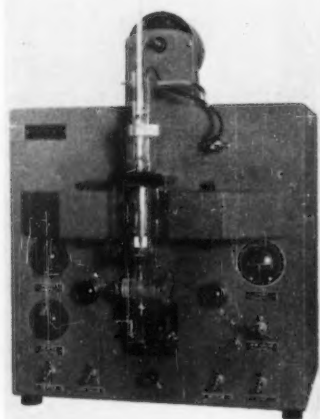
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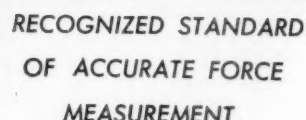
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## News of Members

(Continued from page 96)

Chemists and Colorists Technical Manual and as AATCC coordinator for work on supplements to the Colour Index published jointly by the British Society of Dyers and Colourists and the AATCC. Mr. Appel's ASTM committee service includes 29 years on Committee D-13 on Textile Materials (chairman from 1950 to 1956), Committee D-11 on Rubber and Rubber-Like Materials, E-1, on Methods of Testing, Joint ASTM-TAPPI Committee on Textile Test Methods, and on the Washington, D. C., District Council from 1948 to 1951. Mr. Appel will continue to serve on Committee D-13. Mr. Appel's address is 9101 Jones Mill Rd., Chevy Chase 15, Md.

**Russell Barnard**, whose retirement as advisory engineer from Armeo Drainage and Metal Products Inc., Middletown, Ohio, after 30 years was announced in our January BULLETIN, will move in April to his new home at 6401 Shepherd Hills, Tucson, Ariz. In addition to being an individual member of the Society, Mr. Barnard represented Armeo on Sub IX on Pipe and Tubing of Committee A-1 on Steel from 1934, and on Committee D-18 on Soils for Engineering Purposes from 1953. He was very active in developing a number of the ASTM steel pipe specifications, and participated in the National Emergency Steel project.

**J. Bauer** becomes director of research for automotive divisions of Collins & Aikman Corp., Albemarle, N. C. He held a similar post at the Cavel Plant of the company.

**Dr. I. I. Bessen**, formerly associated with Philips Electronics, Inc., Mt. Vernon, N. Y., is now research supervisor, Physical Metallurgy Section, Research and Development Dept., Jones & Laughlin Steel Corp.

**E. P. Best**, chief metallurgist, A. M. Byers Co., Box 269, Ambridge, Pa., is now director of metallurgy and research.

**George Best**, technical advisor to the general manager of Technical Service, Solvay Process Div., Allied Chemical Corp., Syracuse, N. Y., has been elected vice-president, National Association of Corrosion Engineers.

**Wm. M. Bower**, formerly chief process engineer, Photocircuits Corp., Glen Cove, N. Y., is now senior materials engineer, Bendix Aviation Corp., Kansas City, Mo.

**Edward H. Branson**, a member of ASTM since 1929, retired January 31, 1959, as director of Research Laboratories, General Railway Signal Co., Rochester, N. Y.

**Benson Carlin**, president, Alcar Instruments, Inc., Little Ferry, N. J., has been appointed vice-president and executive director of Circo Ultrasonic Corp., Clark, N. J.

**G. H. Cole** has retired from the Armeo Steel Corp., Middletown, Ohio. Mr. Cole represented Armeo on Committee A-6 on Magnetic Properties since 1947.

**L. O. Crockett**, a former very active member of Committee D-2 on Petroleum Products and Lubricants, has been elected president and chief executive officer of Goodrich-Gulf Chemicals, Inc., Pittsburgh, Pa.

**J. B. Dixon**, member of technical staff, Bell Telephone Laboratories, Inc., Murray Hill, N. J., retired April 1, 1959. Mr. Dixon joined the Society in 1948 and has served on Committee A-5 on Corrosion of Iron and Steel since 1935.

**Richard J. Doerman**, previously research engineer, Admistrues, Inc., San Gabriel, Calif., is now associated with Permanente Cement Co., Los Angeles, Calif., as technical service representative.

**I. Drogin**, director of research, United Carbon Co., Inc., Charleston, W. Va., was unanimously elected a Fellow of the Institution of the Rubber Industry, London, England. Dr. Drogin represents United Carbon Co. on ASTM Committees D-11 on Rubber and Rubber-Like Materials and D-24 on Carbon Black.

**John T. Drow** transferred from U. S. Forest Products Laboratory, Madison, Wis., to assistant director, Division of Forest Products Utilities Research, Forest Service, U. S. Dept. of Agriculture, Washington, D. C.

**D. E. Ellis**, formerly technical director, Pierce & Stevens, Inc., 710 Ohio St., Buffalo, N. Y., has been appointed vice-president in charge of production.

(Continued on page 100)

# PROGRESS IN HARDNESS TESTING

Based upon more than 45 years of experience in hardness testing we are in a better position to recognize and appreciate progress in this art than many other concerns. Here are a few instances of important progress in this field.

Through the development of the REFLEX hardness testing machines (for Brinell, Vickers, Knoop, Grodzinski tests) it has been possible to eliminate the separate microscopic measurement of the indentations. The built-in CARL ZEISS optical equipment automatically projects the greatly magnified images of the indentations on a ground glass screen. It now takes less time to perform a standard Vickers test than a Rockwell test, and the former possesses so much more value.

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## News of Members

(Continued from page 99)

**Roy D. Fasnacht** retired October 1, 1958, as senior materials engineer, Pennsylvania Department of Highways, Harrisburg, Pa. Mr. Fasnacht is continuing his long-time membership in ASTM and is now residing at 4431 N. W. 11th Terrace, Fort Lauderdale, Fla. He has been an active member of Committee C-1 on Cement since 1944.

**Neil A. Fowler**, director of sales and research, General Box Co., Des Plaines, Ill., retired March 31, 1959. Mr. Fowler's first association with the Society was in 1916 when he served as an alternate to a member of the original D-10 Committee on Shipping Containers. In 1929 he became a member of that committee and his personal membership in ASTM dates back to 1936. Mr. Fowler also served as a director of ASTM from 1953 to 1956. In addition, he was a member of the ASTM Ordnance Advisory Committee, and represented the Society on the Government Packaging Industry Advisory Committee.

**Albert A. Frey**, special metallurgist, Wheeling Steel Corp., Wheeling, W. Va., retired December 31, 1958. Mr. Frey joined the Society in 1947 and has given support to the work of Committee A-6 on Magnetic Properties.

**P. V. Garin** is now manager of research and development, Southern Pacific Co., San Francisco, Calif. Previously he was engineer of research and mechanical standards.

**Rome F. Geller**, retired chief of the porcelain and pottery section of the National Bureau of Standards, has been named as the 1959 recipient of the Albert Victor Bleining Award presented by the American Ceramic Society. Mr. Geller is very active in the work of ASTM Committee C-21 and served as its secretary from 1948 to 1954.

**Alice Josephine Gitter**, formerly director of market research, United Mineral and Chemical Corp., New York, N. Y., has been named president of a newly organized firm known as Engineered Materials. Miss Gitter has been a member of ASTM since 1956 and has served on Committee D-9 on Electrical Insulating Materials and as secretary of Committee C-21 on Ceramic Whitewares and Related Products.

**Frederick P. Glazier**, formerly chief project engineer, Wright Aeronautical Div., Curtiss-Wright Corp., Wood Ridge, N. J., is now vice-president, Laboratory Equipment Corp., Mooresville, Ind.

**J. H. Gregory**, director, Chemical Div., Sears, Roebuck & Co., Chicago, Ill., retired at the end of January. Over the years, Mr. Gregory had represented Sears on Committees D-12 on Soaps and Other Detergents, D-11 on Rubber and Rubber-Like Materials, and C-22 on Porcelain Enamel.

**H. E. Halpin**, director of engineering, Factory Mutual Engineering Div., Norwood, Mass., retired recently. Mr. Halpin represented his company in ASTM membership for many years, and will be

succeeded by J. M. Rhodes, director of engineering.

**Joseph W. E. Harrison**, partner, LaWall & Harrison, Philadelphia, Pa., has been given the Honor Scroll of the Pennsylvania chapter of the American Institute of Chemists. The Scroll is given annually to an "outstanding member of the organization for contributions both to the science and to the profession."

**Edward L. Hollady** retired recently as chief, Materials Section, Office Chief of Ordnance, U. S. Department of the Army, Washington, D. C. Since joining ASTM in 1940, Mr. Hollady has been active in the affairs of the Society. Over the years he has served on Committee A-1 on Steel, A-5 on Corrosion of Iron and Steel, A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys, B-5 on Copper and Copper Alloys, D-20 on Plastics, on the Administrative Committee on Simulated Service Testing, and also on the Washington District Council from 1954 to 1956.

**K. M. Huston**, Armco Steel Corp., Baltimore, Md., retired March 1, 1959. At various times, Mr. Huston served on Committees A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys, B-8 on Electrodeposited Metallic Coatings, B-3 on Corrosion of Non-Ferrous Metals and Alloys, D-1 on Paint, Varnish, Lacquer and Related Products, and D-19 on Industrial Water.

(Continued on page 101)

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## News of Members

(Continued from page 100)

**Shiego Kase**, previously chief, Research Dept., Togawa Rubber Manufactory, Sumiyoshi, Osaka, Japan, is now director, Mitsubishi Rubber Co., Ltd., Nagata, Kobe, Japan.

**Helmuth Krainer**, formerly director of research, Gebr Böhler and Co., A. G., Vienna, Austria, is now director, Research Dept., Fried. Krupp, Essen, Germany.

**Robert G. Kuhfeldt** is now associated with Ingenio Pichichi S. A., Buga-Valle, Colombia, as maintenance superintendent. Formerly he was maintenance engineer, Empresa Colombiana de Petroleos, Barrancabermeja, Colombia.

**John Lapin** is now assistant chief engineer, Light Metals, Central Foundry Div., General Motors Corp., Saginaw, Mich. Prior to this time he was chief engineer, Saginaw Bay Industries, Inc., Bay City, Mich.

**Harry M. Levin**, standards engineer, Beckman Instruments, Inc., Systems Div., Anaheim, Calif., is now associated with Epsco-West Div. of Epsco, Inc., Anaheim, Calif., as quality control manager.

**Richard E. Lindberg**, civil engineer, Area Public Works Office, Department of the Navy, San Francisco, Calif., is now civil engineer, Soils, Capitol Engineering Corp., Saigon, Viet Nam.

**Eugene D. Lynch**, formerly associate professor of Ceramic Engineering, University of Illinois, Urbana, Ill., is now associated with Argonne National Laboratory, Lemont, Ill., as associate ceramist.

**Melvin L. Manning** is now dean of engineering, South Dakota State College, Brookings, S. Dak. Formerly he was staff engineer, Pennsylvania Transformer Co., Canonsburg, Pa.

**Clarence B. Marcley**, supervising chemist, Materials and Processes Laboratory, General Electric Co., Schenectady, N. Y., retired recently. Mr. Marcley has been active in the Society since 1951, having served on ASTM Committee D-19 on Industrial Water since that time.

**A. J. Moses**, vice-president and general manager, Hedges-Walsh-Weidner Div., Combustion Engineering, Inc., Chattanooga, Tenn., retired recently. Mr. Moses had been a member of the Society since 1937.

**Beville S. Outlaw, Jr.**, announces that the name of his firm has been changed from Outlaw and Associates to Outlaw, Tucker, and Associates.

**Dr. F. R. Owens** has been elected chairman of the board of directors, and **James K. Rice** has been elected president and general manager of Cyrus Wm. Rice & Co., Pittsburgh, Pa.

**Louis A. Patronskey** is now affiliated with Western Research Div., Timber Engineering Co., Albany, Ore. Formerly he was director of product development, Pack

River Tree Farm Products Co., Spokane, Wash.

**Dr. J. G. Pearce**, director and secretary of the British Cast Iron Research Assn., Birmingham, England since 1924, retired recently. Dr. Pearce is well known for his articles and lectures both in Europe and the United States.

**William Priestley, Jr.**, Esso Research & Engineering Co., Linden, N. J., begins rotational assignment as acting assistant director in process research.

**Walter Ramberg**, chief, Mechanics Division, National Bureau of Standards,

has been appointed science adviser to the U. S. Embassy in Rome.

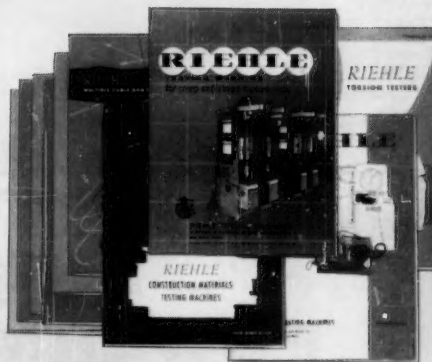
**R. N. St. John**, a member of the Society for 23 years, retired as research engineer, The Coleman Co., Inc., Wichita, Kans. For many years, Mr. St. John served on Technical Committee E on Burner Fuel Oils of Committee D-2 on Petroleum Products and Lubricants.

**Dr. Herbert F. Schiefer**, physicist, Textiles, National Bureau of Standards, Washington, D. C., has been appointed chief of the Textiles Section, succeeding Mr. William D. Appel.

(Continued on page 102)

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## News of Members

(Continued from page 101)

**Morton W. Scott**, formerly senior scientist in the Powder Technology Group of Smith Kline & French Laboratories, Philadelphia, Pa., is now affiliated with the Baby Products Group of Johnson & Johnson, New Brunswick, N. J., as pharmaceutical engineer.

**Bourdon F. Scribner**, chief, Spectrochemical Section, National Bureau of Standards, Washington, D. C., received the Pittsburgh Spectroscopy Award from The Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy Exposition of Modern Laboratory Equipment for outstanding achievement in this field. Dr. Scribner is a very active member of ASTM Committees E-2 on Emission Spectroscopy, E-13 on Absorption Spectroscopy, and E-8 on Nomenclature and Definitions.

**Dr. Robert S. Shane** was appointed engineer, Advance Design Unit, General Design Engineering Subsection, Engineering Section, Light Military Electronics Dept., General Electric Co., Utica, N. Y. Dr. Shane's prior association was with Bell Aircraft Corp., Buffalo, N. Y., as nucleonics specialist.

**Foster D. Snell**, president, Foster D. Snell, Inc., 29 W. Fifteenth St., New York, N. Y., received a scroll of honorary membership in the American Institute of Chemists in New York.

**R. M. Smith**, a member of the Society since 1950, recently retired as vice-president, Union Tank Car Co., Chicago, Ill.

**Norman F. Spooner**, formerly supervisor, Research and Development, Hoskins Manufacturing Co., Detroit, Mich., is now manager.

**Robert D. Stiehler**, rubber technologist, Testing and Specifications Section, National Bureau of Standards, Washington, D. C., has been elected chairman, Rubber & Plastics Div. of The American Society of Mechanical Engineers. Mr. Stiehler is active in the work of ASTM Committee D-11 on Rubber and Rubber-Like Materials.

**Ashton M. Tenney**, retired, Eastman Chemical Products, Inc., New York, N. Y., was elected to honorary membership on Committee D-13 on Textile Materials for the great contributions he made during his term of active association with that committee. Mr. Tenney has been active in the society since 1938.

**Robert H. Tiers** is now president, The Torrington Chemical and Supply Co., Torrington, Conn. Previously he was chief chemist, W. D. MacDermid Chemical Co., Bristol, Conn.

**Townsend Tinker**, chief engineer, Ross Heat Exchanger Division of American Radiator and Standard Sanitary Corp., Buffalo, N. Y., is now vice-president,

Technical Development, of the newly formed Industrial Div.

**S. R. Wallace**, formerly western sales manager, Special Products, United States Pipe and Foundry Co., Chicago, Ill., is now sales manager, Badall Engineering and Mfg. Co., Hammond, Ind.

**E. F. Walsh**, formerly superintendent of production, The Narragansett Electric Co., Providence, R. I., is now engineer of Steam Plant Operation, The New England Power Co., Boston, Mass.

**Henry A. Wiegand**, formerly engineer, Southern Cen-Vi-Ro Pipe Corp., Jacksonville, Fla., is now chief engineer, Florida Section, Concrete Pipe Div., Vulcan Materials Co., Jacksonville, Fla.

**Edward J. Wellauer**, formerly supervisor, Research and Metallurgy, The Falk Corp., Milwaukee, Wis., has been named director, Research and Development.

**Dr. Clyde Williams**, president of Clyde Williams and Co., Columbus, Ohio, and former president and director of Battelle Memorial Institute, is the recipient of the James Douglas Gold Medal of the American Institute of Mining, Metallurgical, and Petroleum Engineers. This medal "recognizes distinguished achievement in nonferrous metallurgy, including both beneficiation of ores and alloying and utilizing of nonferrous metals."

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## DEATHS . . .

**Preston F. Bailey**, manager, Application Engineering, Mine Safety Appliances Co., Pittsburgh, Pa. (recently). Mr. Bailey became affiliated with ASTM in 1957.

**Robinson D. Buck**, partner Buck & Buck, Hartford, Conn. (January 26, 1959). Mr. Buck had been a member of the society for 12 years.

**E. J. Edwards**, before retirement in 1949, representative of the American Locomotive Co. in the society for many years (recently). Mr. Edwards was very active in committee work, particularly A-1 on Steel to which he was elected an honorary member.

**Chester Hacking**, general superintendent, William H. Haskell Mfg. Co., Pawtucket, R. I. (January 8, 1959). Mr. Hacking represented the company in ASTM membership for many years, and served as a member of Committee A-1 on Steel since 1930.

**Walter A. Heinrich**, executive vice-president and director of engineering, James R. Kearney Corp., St. Louis, Mo. (September 19, 1958). Mr. Heinrich joined the society in 1932.

**Gerhardt E. Klapper**, staff engineer, Philadelphia Electric Co., Philadelphia, Pa. (February 27, 1959). Mr. Klapper was one of four men killed in the crash of a helicopter near Conowingo, Md. He was a member of the Joint Committee on Effect of Temperature on the Properties of Metals, and represented the Edison Electric Institute on Committee A-1 on Steel.

**Clarence Lamoreaux**, manager, Research and Development, The Buffalo Slag Co., Inc., Buffalo, N. Y. (February 14, 1959). Mr. Lamoreaux joined the society in 1949, and was very active in the work of Committee C-1 on Cement. In addition, he was a member of the Western New York-Ontario District Council, having served as chairman from 1956 to 1958.

**Orville L. Mills**, Research & Development Div., Lever Brothers Co., Edgewater N. J., (January 22, 1959). Mr. Mills represented Lever Brothers on Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys since 1956.

**William J. Morrow**, technical supervisor Kenosha Div., The American Brass Co., Kenosha, Wis. (August 23, 1958). Mr. Morrow had been a member of the society since 1940.

**Frank J. O'Neil**, 206 Country Club Drive, Greensboro, N. C. (November 29, 1958). Mr. O'Neil joined the Society in 1946, and had been a very active member of Committee D-13 on Textile Materials since that time.

**A. D. Schultz**, ASTM representative of the Eaton Stamping Div., Eaton Manufacturing Co., Cleveland, Ohio (recently).



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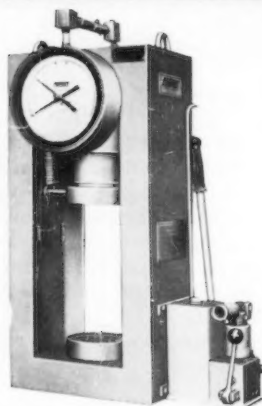
Meets D624-54, D412-51T, D39-49, D1175-55T, D1375-55T, D1117-53, D1230-52T, D1295-53T, D378-51T, D380-51T, D1004-39T Requirements

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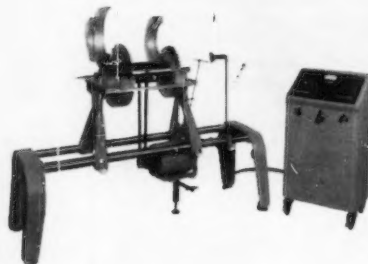


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CIRCLE 180 ON READER SERVICE CARD

## NEWS NOTES ON Laboratory Supplies and Testing Equipment

Note—This information is based on literature and statements from apparatus manufacturers and laboratory supply houses. The Society is not responsible for statements advanced in this publication.

### LABORATORY ITEMS

**Continuous-Gain Amplifier**—The Model 512-A is the most recent addition to the line of d-c amplifiers. It is chopper-stabilized and features eleven fixed gain steps with continuously variable gain between gain settings.

*Allegany Instrument Co., Inc.* 3031

**Beakers**—Beakers, molded from polypropylene for optimum high-temperature service, have been announced.

*American Agile Corp.* 3032

**Dew-Duration Recorder**—Developed in cooperation with USDA scientists, the Amineco Dew-Duration Recorder, which will record the onset and duration of dew deposition, has been announced.

*American Instrument Co., Inc.* 3033

**Reed Electrometer**—A new, vibrating-reed electrometer, capable of measuring  $C^{14}$  activity to  $5 \times 10^{-12}$  curies per mg  $BaCO_3$ ,  $H^3$  activity as low as  $10^{-10}$  curies per mg  $H^3$ , and electrical properties as small as  $10^{-17}$  amp and 0.02 mv, is now being marketed.

*Applied Physics Corp.* 3034

**Retort**—Model RB-1800 retort is used with a vacuum retort furnace for tempera-

tures up to 1800 F. The retort is built integral with a Kanthal-wound furnace and has water-cooled windows for optical creep measuring. The 10-in. diam furnace is 16 in. long.

*Arcweld Mfg. Co.* 3035

**Ultrasonic Testing**—An ultrasonic delay line with extremely low secondary levels and insertion loss as well as wide band width has been developed. This unit, with a delay of 900  $\mu$ sec has an average maximum secondary level of over 70 db below the main delay.

*Arenberg Ultrasonic Lab., Inc.* 3036

**Surface Thermometer**—A new electronic surface thermometer indicating accurate temperature measurements down to  $-328$  F is announced.

*Atkins Technical, Inc.* 3037

**Fade Meter**—A new Fade-Ometer, Model FDA-RC, has been introduced. This Fade-Ometer is equipped with an electrically operated atomizer and cycle meter permitting it to be operated either under conditions simulating the cycling effect and high-humidity conditions encountered in the daylight exposure method or under conditions which produce good correlation with the sunlight exposure method where the samples are exposed to sunlight between 9 a.m. and 3 p.m.

*Atlas Electric Devices Co.* 3038

**Transducers**—High output and low-impedance secondary windings are features of ATC's new smaller differential transformers of which linear stroke is 70 per cent of coil length.

*Automatic Timing & Controls, Inc.* 3039

**Pressure Transmitter**—For providing high-accuracy water-level indication, two models of a proved submersible case are now available for housing Atcotran Bourdon Tube Pressure Transmitter. Type 31-B, of watertight galvanized cast iron, is appropriate for depths of 50 ft or more. Type 31-C is cast brass, watertight, and has applications in lesser depths.

*Automatic Timing & Controls, Inc.* 3040

**Test Bridge**—A new fast-reading Deviation Bridge for comparison testing of resistors, capacitors, and inductors is introduced. The Deviation Bridge model 1505 provides a test frequency of 19,900 cps which is especially useful for testing of magnetic recording heads and audio-frequency transformers.

*B & K Instruments, Inc.* 3041

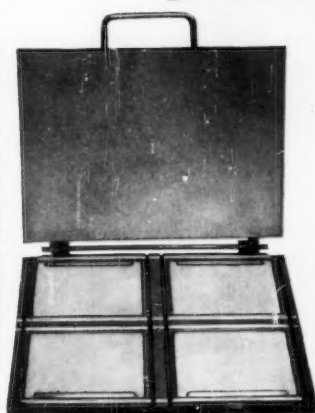
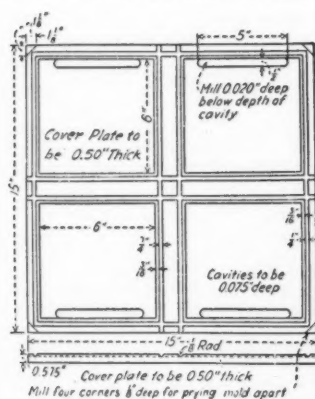
**Switch Indicator**—For rapidly checking temperatures at many points, the 9000 Series Multi-Switch Indicator is available with switching details that allow the instrument to be used for as many as 108 stations.

*Barber-Colman Co.* 3042

## HOGGSON TOOLS, MOLDS AND DIES for rubber testing to ASTM standards

### Die for Cutting "Dumbbell" Samples for Tension Tests

"Dumbbell" dies are milled from steel blocks; edges are carefully ground and specially hardened to cut vulcanized rubber. Entire die precision designed to ASTM standards. Comes as shown for machine operation or with regulation handle for hand use. Hand-forged tensile dies to cut regular or tear test samples also available from stock.



### Precision-Cut Slab Molds

For making tensile test samples, we supply single and multicavity slab molds as shown; plain or chrome finish, with or without handle and hinges. We usually stock all necessary molds for making adhesion, abrasion, flexing, compression and rebound test samples. Special molds to your order promptly.

Shown here is but a suggestion of the Hoggson designs available. Please describe your need and we will send detailed information.



BENCH MARKER  
1" and 2" Centers

**HOGGSON & PETTIS MANUFACTURING CO.**  
133 BREWERY ST., NEW HAVEN 7, CONN.

Pac. Coast: H. M. Royal, Inc., Downey, Calif.



## Laboratory Items

(Continued from page 105)

**Ultraviolet Microscope**—The first ultraviolet microscope which permits visual focusing by use of the new RCA "ultra-scope tube" is available. Now the photomicrographer can visually focus the image using ultraviolet light.

*Bausch & Lomb Optical Co.* 3043

**Bearing Tester**—Easy, accurate, non-destructive testing of precision ball and roller bearings is now made possible by the Model BA-22 Electronic Bearing Tester.

*Bearing Inspection, Inc.* 3044

**Embrittlement Detector**—The Embrittlement Detector is a device that may be attached to a boiler to indicate the tendency of the boiler water to cause intercrystalline cracking. It is designed to reproduce the physical and chemical conditions that may exist in a riveted seam or rolled-in tube end.

*Betz Laboratories, Inc.* 3045

**Recorder**—An Analog and Operations Recorder, developed to military requirements and specifications (MIL E-4158-E-4970), has been developed. The new recorder permits simultaneous recordings of two types: analog recording of the 0 (dc) to 100 cps range with wide amplitude and writing speeds; "on-off," "go and no-go," and sequential types of events on 10 separate channels.

*Brush Instruments  
Clevite Corp.* 3046

**Accelerometers**—A complete line of crystal accelerometers which operate in an ambient temperature range between -65

and 540 F without cooling or correction has been introduced.

*Columbia Research Laboratories* 3047

**Test Chamber**—Model FB-30, a high-low-temperature test chamber, with a range of -100 to 300 F is announced. Standard equipment on the chamber includes a 24 by 24-in. multipane viewing window, externally mounted ball-bearing circulator motor, and an electrical panel equipped with a manual disconnect switch for servicing.

*Conrad, Inc.* 3048

**Mass Spectrometer**—Modifications of Type 21-620 Mass Spectrometer permit analysis of light liquids and gaseous mixtures over a mass range previously possible only with large permanent laboratory installations.

*Consolidated Electrodynamics Corp.* 3049

**Vacuum Gage**—A thermal-conductivity type, constant-temperature vacuum gage having excellent sensitivity in two ranges, from 1 to 100 microns and from 1 micron to 500 mm is now available.

*Consolidated Electrodynamics Corp.* 3050

**Transformer Indicator**—Accurate, large-scale indication and recording of linear motion, size, weight, force, pressure, and other quantities measurable by differential-transformer transducers is achieved with the new Model 300A Differential Transformer Indicator.

*Daytronic Corp.* 3051

**Digital Micrometer**—Automatic scanning and printing of dimensional data with accuracy to 0.001 in. is achieved with the new Model 700 Digital Micrometer and

accessory items.

*Daytronic Corp.* 3052

**Sonics**—Introduction of a new model Econo-Sonic Unit that is a complete cleaning, distillation, and filtration system in itself is announced. This new ultrasonic unit pre-cleans, ultrasonic cleans, and pressure-spray rinses.

*Detrez Chemical Industries, Inc.* 3053

**Micrometer**—A new direct-reading, digital read-out, electronic micrometer capable of making 20 or more readings per minute to accuracies of 0.000020 in. has recently been announced. The instrument is specifically designed for production use by unskilled operators and is particularly suitable for industries working with fragile or compressible materials.

*J. W. Dice Co.* 3054

**Low-Temperature Thermometer**—Temperature measurements of -57 C (-70 F) are possible with mercury-thallium filled thermometers developed especially for low temperatures.

*The Eldridge Co.* 3055

**Tri-Axial Accelerometer**—Accurate simultaneous measurement of vibration along three axes can now be accomplished with the new Endevco Model 2223 Tri-Axial Accelerometer. Three Endevco Piezite Type I sensing elements are mounted in mutually perpendicular planes within a 1-cu-in. block weighing 1.4 oz.

*Endevco Corp.* 3056

**Surface Finish Tester**—Talsurf Model 100, just introduced in this country, is a portable, universal instrument, semi-automatic in its operation yet suited to a wide range of production-inspection applications in the precision testing of surface finish.

*Engis Equipment Co.* 3057

**Roundness Tester**—The new Model 50 Talyrond Roundness Measuring Instrument provides accuracies of 0.000002 in. or better over a capacity of 12-in. ID or OD and 10 in. height.

*Engis Equipment Co.* 3058

**Rack Cabinet**—The FT-192 is a standardized rack cabinet designed for a wide variety of uses with or without accessories now being offered.

*Falstrom Co.* 3059

**Hydrogen Analyzer**—A compact, easy-to-operate apparatus designed especially for the laboratory that must measure the amount of dissolved hydrogen in metals or other solid materials is now being offered.

*Fisher Scientific Co.* 3060

**Viscosity Tubes**—These tubes meet the requirements of ASTM Method D 1545-58 T, Test for Viscosity of Transparent Liquids by Bubble Time Method.

*Gardner Laboratory, Inc.* 3061

**Graphic Level Recorder**—A pen-type, Model 1521-A, servo-operated, completely transistorized recorder is offered. It plots the rms level of a-c voltages from 20 cps to 200 kcps and can also be used as a linear d-c recorder.

*General Radio Co.* 3062

**Bottle Carrier**—A thick-walled polyethylene container is available to replace leather or canvas carriers for acid bottles, etc.

*General Scientific Equipment Co.* 3063

**Test Cabinets**—Answering the need for extra-capacity, high-accuracy test cabinets for bulky specimens, assemblies,

# Atlas-Ometers

...Used all over the world

Give quick accurate answers to the deteriorating effect of sunlight, weathering, washing and wearing of materials. A few minutes, hours, or days in Atlas-Ometers equals years of normal use deterioration.

Indispensable for speed testing in product development and quality control in production. Exact standardized test programs can be repeated as frequently as required.

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Fade-Ometer®



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Random Tumble  
Pilling Tester



Accelerator®

Weather testing translucent fiberglass for outdoor use in an Atlas Weather-Ometer at the Alsynite Company of America.

FOR FURTHER INFORMATION CIRCLE 182 ON READER SERVICE CARD

## Laboratory Items

and quantity (batch-type) testing, with all atmospheres, is the new line of "King-Size" G-S Accelerated Corrosion Test Cabinets.

G. S. Equipment Co. 3064

**Metal Microtome**—The new microtome known as the Model "KM" is electrically operated and of extremely sturdy construction. In designing this new unit, the principle of the sliding microtome was retained. Depending on the character, the specimen is either mounted in resin or placed unmounted into the vise-type object holder.

William J. Hacker & Co., Inc. 3065

**Tester**—A new portable instrument, the Hunter Terminal Pull Tester, is available to test the tensile strength of electrical connections of all types.

Hunter Spring Co. 3066

**Micro Volt-Ammeter**—The Model 150 is an ultra-sensitive, multipurpose instrument for measuring or amplifying extremely small d-c potentials. It may be used as an amplifier, micro-microammeter, and (with an external voltage supply) meg-megohmmeter.

Keithley Instruments, Inc. 3067

**Package Tester**—A new compression testing machine specifically designed for testing shipping containers, packages, and packaging material has been announced.

L. A. B. Corp. 3068

**Combustion Capsule**—Development of a new tin capsule for combustion analyses is announced. The capsule will handle both organic and inorganic samples in either powder or liquid form, and can be used for carbon, sulfur, oxygen, hydrogen, and other important analyses.

Laboratory Equipment Corp. 3069

**Recorders**—Measurements of pressure, flow, and other variables, detected by 3-terminal potentiometer (resistance) transducers, can now be accurately indicated and recorded by a new adaption of the Speedomax Type II instrument.

Leeds & Northrup Co. 3070

**Air Sampler**—The Airborne Particle Sampler is used to collect radioactive airborne particles in specific areas in the laboratory or industrial plant to determine possible air contamination when working with volatile radioactive materials; or it can be used for general air pollution analysis and control.

## CATALOGS & LITERATURE

**Analytical Balance**—Bulletin 359 describes the new automatic-recording analytical balance. This electronic instrument for thermogravimetric analysis records both weight and temperature against time.

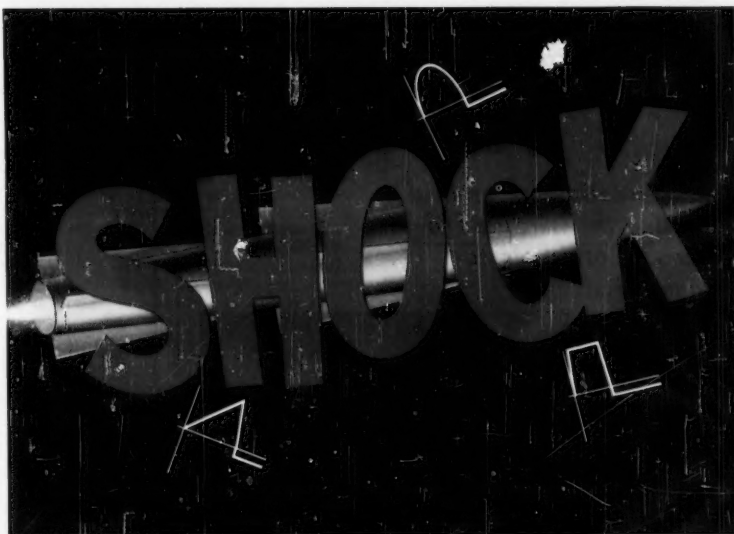
Wm. Ainsworth & Sons, Inc. 6017

**Wear-In**—Bulletin 120, a new 2-color bulletin on Molykote Wear-In Compound has been published. It discusses the effectiveness of the new compound in eliminating damage due to improper breaking-in of new or rebuilt machinery.

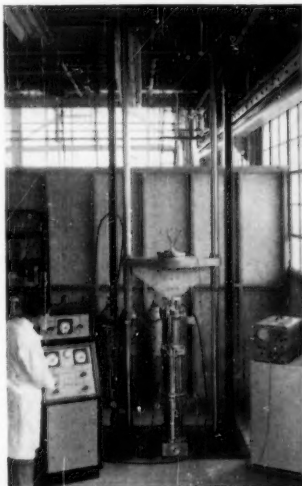
The Alpha-Molykote Corp. 6018

**Strain Gage**—A new catalog of SR-4 Strain Gages, instruments, and accessories has been released. Containing over 250 types, this latest catalog is an authority.

(Continued on page 109)



## Only HYGE can produce and repeat so many different kinds of shock



60-second test simulates exact service conditions, records shock waves on oscilloscope for instant reference or photography.

What shock situation would you like to set up? Shock loads to missile launcher? Re-entry—to atmosphere, land or water? Rocket fuel handling? Parachute landing? Underwater or underground explosion? You can simulate them all with HYGE . . . and repeat each one exactly . . . for only pennies per test. And as new test requirements develop, an inexpensive metering pin adapts HYGE to meet them. You have a permanent source of stored energy—variable, to meet your needs, up to 40,000 lbs. thrust—with versatility for a wider range of shock wave patterns than with any other equipment. If shock is a factor in the success of your project, you'll want to know more about HYGE.

Write for Bulletin 4-70 . . . theory, application and specification data on HYGE Shock Testers.

## Consolidated Electrodynamics

Rochester Division, Rochester 3, N.Y.

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# Shore DUROMETER

*The "International Standard"  
for testing the hardness of  
rubber and other elasto-  
meric materials*

### FEATURES:

- Quadrant or round dial for fast and accurate reading

- Conforms to ASTM D 676-58 T and ASTM D 1484-57 T

- Small enough to be carried in the pocket

- Furnished complete with carrying case and standard test block.



The Shore Durometer is available in various models for testing the entire range of rubber hardness.

Write for FREE Descriptive Literature

Made by the manufacturers of the "Scleroscope", for testing the hardness of metals.

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## Catalogs & Literature

(Continued from page 107)

tive listing of bonded-filament resistance strain gages.

Baldwin-Lima-Hamilton Corp. 6019  
Electronics and Instrumentation Div.

**Testing Damping Materials**—Techniques and theory are described in *Technical Review No. 1 and 2*, containing 16 and 24-page articles, for the objective measurement of the damping effect of surface coating material for reducing noise and vibration.

B & K Instruments, Inc. 6020

**Optical Catalog**—Optical Products is a 24-page illustrated index which lists current Bausch & Lomb catalogs. It is divided into consumer, ophthalmic and scientific, and technical products classifications, corresponding to the major product divisions of the company.

Bausch & Lomb Optical Co. 6021

**Chromatography**—Now available is a specifications sheet, *Bulletin 752*, describing a new accessory for recording gas chromatograph column or sample inlet temperature directly on the recorder chart.

Beckman Scientific Instruments 6022

**Temperature Probe**—*Bulletin 1048* on moving temperature probe which patrols critical boiler gas passages and gives adequate warning of incipient hot spots during lighting-off is now available.

Blaw-Knox Co. 6023

**Temperature Control**—A 4-page, 2-color brochure illustrating and describing

mechanical-convection industrial-batch ovens, utility ovens, aging ovens, drawer ovens, dry-type incubators, dry-air sterilizers, and environmental cabinets is available.

Blue M Electric Co. 6024

**Pressure Transducers**—Three new instrumentation bulletins technically describing a series of rugged, high-performance pressure transducers are available. Model DP-7 Pressure Transducer, Model GP-15D High Range Pressure Transducer and Model DP-15D High Range Differential Pressure Transducer bulletins contain instrument descriptions, application information and performance specifications.

Borg-Warner Corp. 6025

**Chemicals and Reagents**—A 36-page book containing a complete alphabetical listing of the various reagent chemicals, indicators, stains and culture media, and solutions which are in greatest demand from laboratories has been announced.

Central Scientific Co. 6026

**Industrial TV Cameras**—A 4-page bulletin giving complete specifications for two cameras, Model 1986C and Model 1986CN is available.

Cohu Electronics, KIN-TEL Div. 6027

**Electronic Balance**—A 2-page bulletin describing in detail a new range and balance unit is now available.

Computer Engineering Associates, Inc. 6028

**Control Center**—Four-page brochure illustrates and describes typical custom control centers for all types of automation systems and automatic machinery.

Control Design and Fabricate, Inc. 6029

**Ultra-High-Speed Lens**—*Bulletin No. 8218* describes the Super-Farron  $f/0.87$  lens, a new ultra-high-speed objective, and graphically illustrates spherical aberrations and other characteristics of the Super-Farron as compared with six other high-speed lenses.

Farrand Optical Co., Inc. 60 0

## INSTRUMENT COMPANY NEWS

**Branson Instruments, Inc., Stamford, Conn.**—Has opened a factory branch at 12438 Ventura Blvd., Studio City, Calif. A staff of factory-trained personnel will be under the supervision of Kenneth P. Hayes, who has been with Branson since 1951. The company's former service manager, F. Kenneth Smith, will head the installation and repair department at the new location.

**Macalaster Bicknell Co., Providence, R. I.**—Announces the opening of Macalaster Bicknell Co. of Rhode Island with office and warehouse at 221 Exchange St., Providence, R. I. The company, which manufactures and distributes laboratory supplies and equipment, also has plants at New Haven, Conn., Syracuse, N. Y., Millville, N. J., and Fitzwilliam, N. H.

**E. H. Sargent & Co., Chicago, Ill.**—Manufacturer and distributor of scientific laboratory equipment, is now serving laboratories throughout the East with the opening of its new Eastern Division plant at 35 Stern Ave., Springfield, N. J.

## The NEW double action SYNTRON

Vibrating

### TEST SIEVE SHAKERS

produce uniform, dependable  
analyses, faster

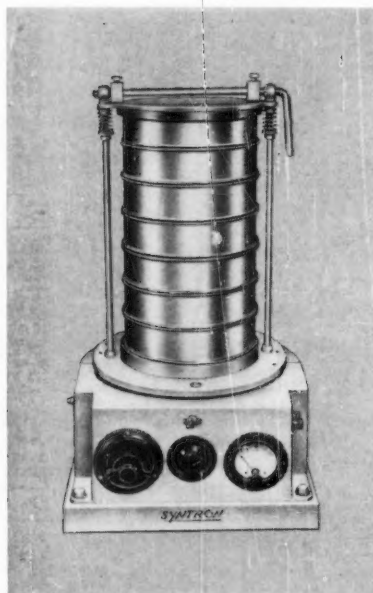
SYNTRON'S New Electromagnetic Test Sieve Shakers provide a thorough analysis in less time than with older fashioned machines. Utilizing both vertical and rotating vibration, they produce a double vibrating action for faster testing.

SYNTRON Test Sieve Shakers produce quick, accurate analyses of accurately timed test periods. They are easy to operate and the absence of mechanical wearing parts assures dependability and low maintenance.

#### SYNTRON TEST SIEVE SHAKERS FEATURE:

- Double action electromagnetic drive—3600 controllable vibrations per minute.
- Rheostat voltage control
- Reset timer for accurate time testing
- Voltmeter
- Will hold 6-standard 8-inch test sieves and bottom pan
- Operation from 115 volt, 60 cycle a-c

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### ENGRAVED STEM GLASS THERMOMETERS

- From 5" to 24", round or lens type. Ring or button top. Nickel plated brass or stainless steel armors.

### A.S.T.M. THERMOMETERS

- Precision engraved stem glass thermometers manufactured to American Society for Testing Materials specifications.

### HYDROMETERS & ACCESSORIES

- Quality instruments for all applications; light or heavy liquids, calcium chloride, spirits, sugar, petroleum products, etc.

### SOCKETS AND TEST WELLS

- Separable sockets for use with indicating and recording thermometers. Test wells for engraved stem thermometers. In all metals.

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FREEPORT, L.I., NEW YORK

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## Cady Testing Instruments are Known



## for Accuracy and Dependability

FOR BURST TEST  
FOR THICKNESS  
FOR BASIS WEIGHT



Complete line of desk, lab and portable micrometers, Burst Testers, Scales . . .



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## Federal Government Standards Index Changes

THE FEDERAL Supply Service of the General Services Administration is charged with the responsibility for establishing specifications to be used by the Federal Government for procurement of materials and supplies. The GSA issues an annual Index of Initiation of Federal Specifications Projects, and monthly supplements.

The items listed below appeared in Supplements Nos. 10 and 11 for the months of December 1958 and January 1959.

### INITIATIONS

Title	Type of Action	Symbol or Number	FSC Code	FSSC Class	Assigned Agency & Preparing Activity
Identification Marking of Aluminum, Magnesium, and Titanium.....	New	Fed. Std. 184	..	..	GSA-FSS
Aluminum Alloy Bars, Rods, and Shapes, Extruded 6061-6062.....	Rev.	QQ-A-270a	9530, 9540	..	DOD USAF
Boxes, Wood, Nailed and Lock-Corner.....	Am. 2	PPP-B-621	8115	..	DOD-Navy-S&A
Burners, Bunsen, Laboratory.....	Rev.	GG-B-817a	6640	..	GSA-FSS
Cellulose Acetate Plastic Sheets.....	Rev.	L-C-169	9330	51	DOD-Navy-Ships
Cleaning Compound, Toilet Bowl.....	Am. 3	O-C-426d	7930	..	DOD-Army-QMC
Fiberboard, Insulating.....	Rev.	LLL-F-003221b	..	..	DOD-Army-CE
Flannel, Cotton, Heavy (for Table Felts).....	Rev.	CCC-F-456a	8305	..	DOD-Army-QMC
Hardboard Panels, Prefinished.....	New	LLL-H-0060 (Army-CE)	..	..	DOD-Army-CE
Leather, Methods of Sampling and Testing..	Am. 4 Part-3	KK-L-311a	..	..	COM-NBS
Molding Plastic, Polyvinyl Chloride, Rigid.....	Am. 1	L-M-530a	9330	..	DOD-Navy-Ships
Paint, Ready Mixed, International Orange.....	Rev.	TT-P-59c	8010	..	GSA-FSS
Paint, ReflectORIZED Drop-in-Type (for Air Field Runways).....	New Rev.	TT-P-85a TT-P-0083 (Army-CE)	8110	..	DOD-Army-CE
Sealer and Lubricant for Wood Furniture.....	New	TT-S-180a	8010	..	GSA-FSS
Shingles, Asphalt, Mineral-Surfaced, Uniform Thickness.....	Am. 1	SS-S-300	5650	..	GSA-FSS
Soap, Scouring, Cake Form.....	Int. Am. 1	P-S-571c	7930	51	GSA-FSS
Wax, Floor, Water-Emulsion, Slip-Resistant....	Rev.	P-W-155a	7930	..	GSA-FSS
Webbing, Elastic.....	Rev.	JJ-W-155a	8415	84	DOD-Army-QMC
Wire, Steel, High-Carbon, Spring, Bright Music..	Am. 2	QQ-W-470a	9505	..	DOD-Navy-Ord.

### TITLE CHANGES

Title	Type of Action	Symbol or Number	Former Title
Antifreeze, Ethylene Glycol, Inhibited.....	Rev.	O-A-548	Ethylene Glycol, Inhibited
Paint, ReflectORIZED Traffic Ready-Mixed Type (for Roadway Marking).....	New Rev.	TT-P-87b TT-P-0087a (Army-CE)	Paint Traffic ReflectORIZED
Sweeping Compound (Absorbent Material, Oil and Water).....	New	P-S-865a	Absorbent Material, Oil and water, for Floors and Desks

### PROMULGATIONS

Title	Type of Action	Symbol or Number
Acoustical Units, Prefabricated.....	Am. 3	SS-A-118b
Adhesive Compound, Fatty Acid Pitch Base, for Use with Fiberglass, Roofing Felts, Roll Roofing, Roofing Fabric (Superseding SS-A-00150a (RHF-PHA)).....	New	SS-A-150b
Antifreeze, Ethylene Glycol, Inhibited (Superseding O-A-00548 (GSA-FSS) & O-E-771a).....	New	O-A-548a
Cable & Wire, Weather-Resistant.....	Am. 3	J-C-145

Cellophane (Coated and Noncoated Regenerated Cellulose Film) (Superseding L-C-00110b (GSA-FSS) & L-C-110a).....	Rev.	L-C-110c
Insulating Oil, Electrical (for Transformers, Switches, and Circuit Breakers) (Superseding VV-0-401).....	New	VV-1-530
Metal Cleaner, Phosphoric Acid Base.....	New	P-M-200
Mortar and Pestle (Superseding GG-M-00621a (HEW-PHS) & GG-M-621).....	Rev.	GG-M-621b
Packaging, Packing, and Marking of Textile Fabrics (Woolens, Worsteds, Cottons, Silks, and Synthetics) (Superseding PPP-).....	Rev.	PPP-P-51a
Pigment, Chrome-Green, Pure, Dry (Superseding TT-C-00235a (GSA-FSS) & TT-C-235).....	New	TT-P-345
Pigment, Iron Oxide; Black, Synthetic, Dry (Superseding TT-I-00698a (GSA-FSS) & TT-I-698).....	New	TT-P-390
Pigment, Iron-Blue, Dry (Superseding TT-I-00677a) (GSA-FSS) & TT-I-677).....	New	TT-P-385
Pigment, Iron Oxide; Brown, Synthetic, Dry (Superseding TT-I-00702a (GSA-FSS) & TT-I-702).....	New	TT-P-395
Pigment, Molybdate Orange (Superseding TT-M-00570 (Navy).....	New	TT-P-410
Pigment, Ultramarine Blue; Dry (Superseding TT-U-00450a (GSA-FSS) & TT-U-450).....	New	TT-P-450
Pigment, Umber, Raw and Burnt, Dry (Superseding TT-U-00481a (GSA-FSS) & TT-U-481).....	New	TT-P-455
Plastic Sheet, Corrugated, Translucent, Glazing, Primer-Surfacer; Synthetic, Tints and White (for metal and Wood Surfaces) (Superseding TT-P-659).....	New	L-P-505
Road and Paving Materials; Methods of Sampling and Testing.....	Rev.	TT-P-659a
Sealing Compound, Jet-Fuel Resistant, Hot Applied, Concrete Paving (Superseding SS-S-00167a (Army-CE) & SS-S-167).....	Am. 1, Pt-2	SS-R-406c
Surfacer, Liquid, Sanding, Synthetic (Alkyd) Base, (For Metal and Wood Surfaces) (Superseding TT-S-810).....	Rev.	SS-S-167b
	Rev.	TT-S-810a

#### INTERIM FEDERAL SPECIFICATIONS AND STANDARDS ISSUED

Title	Type of Action	Symbol or Number
Cleaning Compound, Synthetic Detergent (Non-abrasive).....	Am.	P-C-00431b (GSA-FSS)
Dust Mop Treating Compound.....	Am. 1	P-D-00800 (GSA-FSS)
Gold Leaf.....	Rev.	QQ-G-00566b (INT-NPS)



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Accurately measures coefficient of linear expansion of specimens up to  $\frac{1}{2}$ " in diameter and from 2" to 3" long, at temperatures up to 1000° C. Dial gage readings to 0.0001".

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### The Gaertner Scientific Corporation

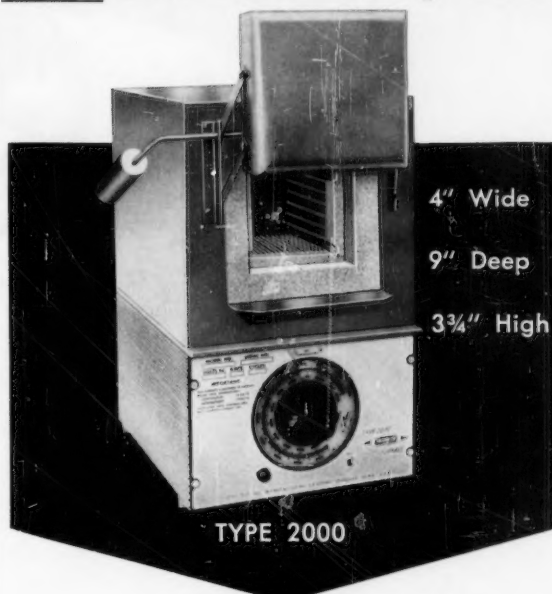
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# ACCURATE

$\mu$ ,  $r_p$ , and  $g_m$

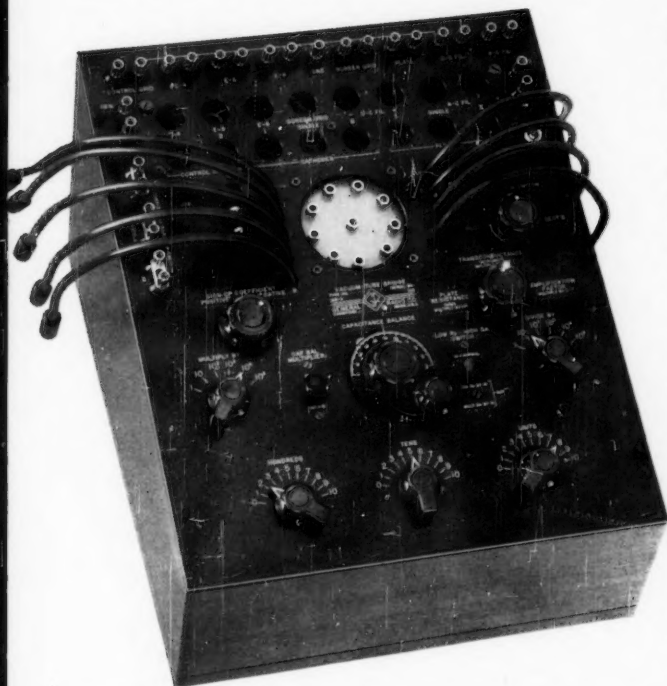
## STANDARD for VACUUM TUBES

$h_i$ ,  $h_r$ ,  $h_f$  and  $h_o$  for TRANSISTORS



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An up-to-date design incorporating many improvements for increased versatility and convenience



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★ Transistor parameters can be measured quickly and easily;  $h_i$  and  $h_r$  are given directly,  $h_f$  ( $\alpha$  or  $\beta$ ) and  $h_o$  are readily calculated.

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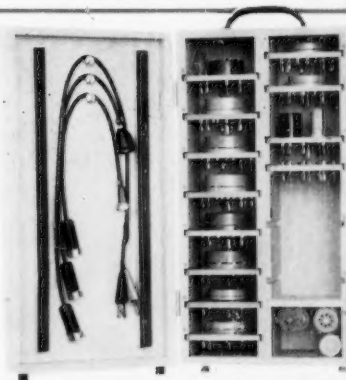
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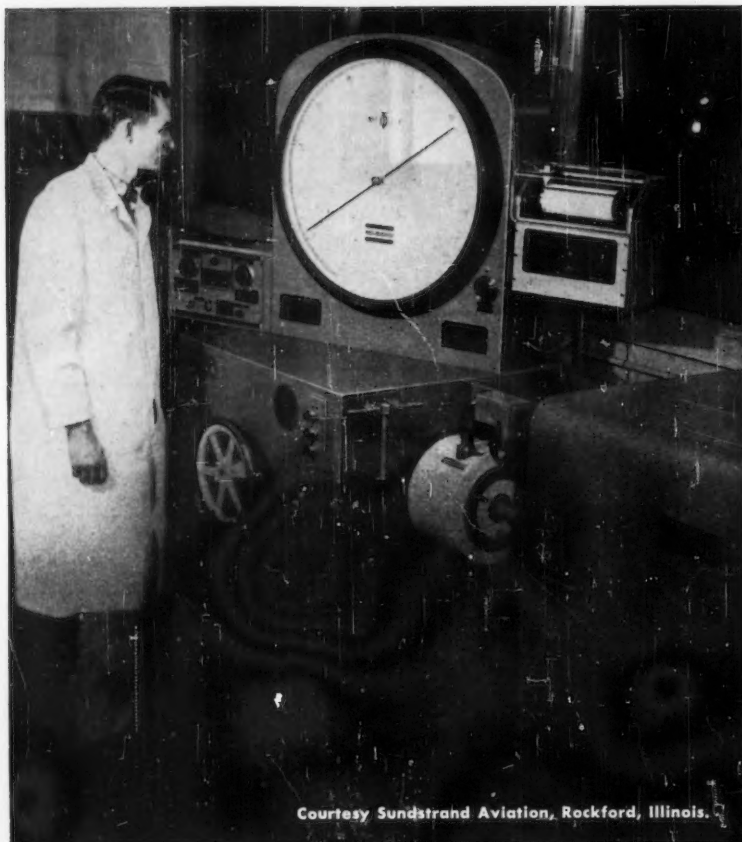
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